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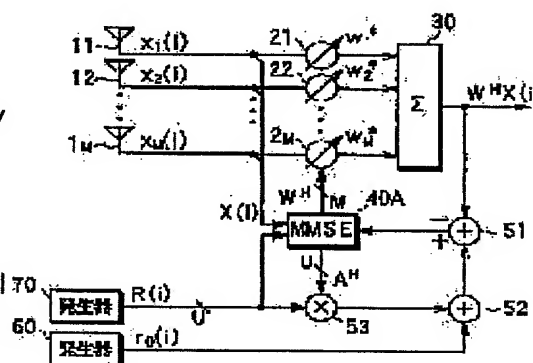
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(54) ADAPTIVE ARRAY ANTENNA

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an array antenna of an MMSE(minimum mean square error) system, in which wasteful consumption with respect to degrees of freedom is suppressed.

SOLUTION: A generator 60 generates a preamble signal $r_0(i)$ of an OFDM(orthogonal frequency division multiplexing) signal, and a generator 70 generates a delay signal $R(i)$ for the signal $r_0(i)$. A multiplier 53 multiplies the delay signal $R(i)$ by a signal weight AH to output a multiplied signal $\{AHR(i)\}$. An adder 52 outputs an added signal $(r_0(i)+AHR(i))$. An adder 51 determines an error $e(i)$, between the added signal and the inner product signal $WHX(i)$ of an adder 30. An MMSE calculator 40a updates an antenna weight W and a signal weight A , to make the error $e(i)$ small. The inner product signal $WHX(i)$ of an adder 30 is made to be a signal formed, by suppressing the components of a received OFDM signal $X(i)$, except for the preamble signal $r_0(i)$ and the delay signal $AHR(i)$.



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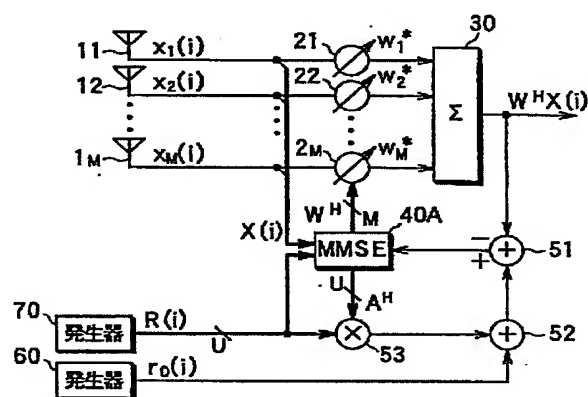
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(54) 【発明の名称】 アダプティブアレーアンテナ

(57) 【要約】

【課題】 自由度の無駄な消費を抑えるようにしたMMSE方式のアダプティブアレーアンテナを提供する。

【解決手段】 発生器60はOFDM信号のプリアンブル信号 $r_o(i)$ を発生し、発生器70はプリアンブル信号 $r_o(i)$ に対する遅延信号 $R(i)$ を発生する。乗算器53は信号ウェイト A^H を遅延信号 $R(i)$ に乗算して乗算信号 $\{A^H R(i)\}$ を出力する。加算器52は、加算信号 $\{r_o(i) + A^H R(i)\}$ を出力する。加算器51は、加算信号と加算器30の内積信号 $W^H X(i)$ との誤差 $e(i)$ を求める。MMSE演算器40Aは、誤差 $e(i)$ を小さくするようにアンテナウェイト W 及び信号ウェイト A を更新する。加算器30の内積信号 $W^H X$ は、受信OFDM信号 $X(i)$ のうちプリアンブル信号 $r_o(i)$ と遅延信号 $A^H R(i)$ とを除く成分が抑圧された信号になる。



【特許請求の範囲】

【請求項 1】 複数のアンテナ素子 (11…1M) と、前記複数のアンテナ素子で受信された受信信号にそれぞれのアンテナウエイトを乗算するアンテナ乗算手段 (21…2M) と、前記アンテナウエイトが乗算されたそれぞれの受信信号を加算して加算信号を出力する加算手段 (30) と、第 1 の既知信号及び第 2 の既知信号から参照信号を求める参照信号算出手段 (51～53、51A、53A) と、前記複数のアンテナ素子で受信された受信信号と前記加算信号と前記参照信号とに応じて前記アンテナウエイトを更新する更新手段 (40A、41) とを備えることを特徴とするアダプティブアレーアンテナ。

【請求項 2】 前記第 2 の既知信号は、前記第 1 の既知信号に対して所定期間遅延した遅延信号であることを特徴とする請求項 1 に記載のアダプティブアレーアンテナ。

【請求項 3】 前記第 1 の既知信号を前記所定期間遅延させて前記第 2 の既知信号を求める遅延手段 (80) を有することを特徴とする請求項 2 に記載のアダプティブアレーアンテナ。

【請求項 4】 前記複数のアンテナ素子は、それぞれ、前記第 1 の既知信号の成分と前記第 2 の既知信号の成分とを有する信号を前記受信信号として受信し、前記複数のアンテナ素子で受信された受信信号に基づいて、前記第 1 の既知信号の成分に対する前記第 2 の既知信号の成分の遅延時間を求める遅延時間算出手段 (100) を有し、

前記遅延手段は、前記所望既知信号を前記遅延時間だけ遅延させて前記第 2 の既知信号を求めることを特徴とする請求項 2 に記載のアダプティブアレーアンテナ。

【請求項 5】 前記第 1 の既知信号に対してそれぞれ異なる時間だけ遅延した複数の遅延信号を生成する遅延信号生成手段 (90) と、前記複数の遅延信号と前記受信信号との相関検出を行う相関検出器 (131a～134c) と、前記相関検出器の相関検出に基づいて前記複数の遅延信号の何れかを前記第 2 の既知信号として選択する選択手段 (135a～136) とを有することを特徴とする請求項 2 に記載のアダプティブアレーアンテナ。

【請求項 6】 前記参照信号算出手段は、前記第 2 の既知信号に信号ウエイトを乗算するウエイト乗算部 (53) を備え、この信号ウエイトが乗算された前記第 2 の既知信号に前記第 1 の既知信号を加算して前記参照信号を求め、

前記更新手段は、前記複数のアンテナ素子で受信された受信信号と前記第 2 の既知信号と前記参照信号と前記加算信号とに応じて前記信号ウエイトを更新することを特徴とする請求項 1～5 のうちいずれか 1 つに記載のアダ

プティブアレーアンテナ。

【請求項 7】 前記加算手段の加算信号のうち前記第 2 の既知信号の成分を抑圧するために帰還信号を加算する抑圧手段 (129、130) と、前記加算信号を所定期間だけ遅延させて遅延加算信号を生成する加算信号遅延手段 (121～124) と、前記遅延加算信号に前記信号ウエイトを乗算して前記帰還信号を求める乗算手段 (125～128) とを有することを特徴とする請求項 6 に記載のアダプティブアレーアンテナ。

【請求項 8】 複数のアンテナ素子 (11…1M) と、前記複数のアンテナ素子で受信された受信 OFDM 信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段 (801～80M) と、前記周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段 (201～20M) と、前記アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段 (300) と、所望 OFDM 信号が周波数弁別された所望弁別信号を求める所望周波数分別手段 (84) と、前記所望弁別信号に対して遅延した遅延弁別信号を求める遅延手段 (90、83) と、前記遅延弁別信号に信号ウエイトを乗算して、この信号ウエイトが乗算された前記遅延弁別信号に前記所望弁別信号を加算して参照信号を求める参照加算手段 (510、520、530) と、前記それぞれの弁別信号と前記遅延弁別信号とに応じて前記参照信号に前記加算信号を近づけるようにして、前記それぞれの弁別信号のうち前記所望弁別信号及び遅延弁別信号の双方を除く成分を抑圧するように前記アンテナウエイト及び前記信号ウエイトを更新する更新手段 (40B) とを備えることを特徴とするアダプティブアレーアンテナ。

【請求項 9】 複数のアンテナ素子 (11～14) と、前記複数のアンテナ素子で受信された受信 OFDM 信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段 (801～804) と、前記周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段 (201～204) と、前記アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段 (300) と、所望 OFDM 信号に対して所定期間遅延した遅延 OFDM 信号を求める遅延手段 (80A) と、前記所望 OFDM 信号及び前記遅延 OFDM 信号の双方が周波数弁別された所望弁別信号を求める所望周波数分別手段 (834) と、前記所望弁別信号に信号ウエイトを乗算して参照信号を求める参照加算手段 (530A) と、

前記参照信号と前記加算信号とを加算して加算参照信号を求める加算参照信号算出手段(510A)と、
前記加算参照信号のうち、前記所望弁別信号の成分を除く成分の電力を小さくするように前記アンテナウエイト及び前記信号ウエイトを更新する更新手段(42)とを備えることを特徴とするアダプティブアレーアンテナ。

【請求項10】 既知信号が周波数軸上に配列されたブリアンブル信号を、前記所望OFDM信号として生成する生成手段(60)を有することを特徴とする請求項8又は9に記載のアダプティブアレーアンテナ。

【請求項11】 前記受信周波数弁別手段は、前記受信OFDM信号をサンプリングして各サンプリング信号を得て、前記各サンプリング信号に応じて前記弁別信号を求め、

前記遅延時間は、前記サンプリングの周期の所定倍数であることを特徴とする請求項10に記載のアダプティブアレーアンテナ。

【請求項12】 前記遅延手段は、所望個数の前記遅延弁別信号を出力することを特徴とする請求項8～11のいずれか1つに記載のアダプティブアレーアンテナ。

【請求項13】 前記遅延弁別信号の所望個数は、前記所望OFDM信号のデータ信号のガードインターバル期間と、前記サンプリングの周期と、によって決まる最大個数であることを特徴とする請求項12に記載のアダプティブアレーアンテナ。

【請求項14】 前記参照信号算出手段は、前記第1及び第2の既知信号に信号ウエイトを乗算して前記参照信号を求める手段(53A)と、
前記参照信号と前記加算信号とを加算して加算参照信号を求める手段(51A)とを有し、
前記更新手段(41)は、前記加算参照信号のうち、前記第1及び第2の既知信号を除く成分の電力を小さくするように前記アンテナウエイト及び前記信号ウエイトを更新することを特徴とする請求項2又は3に記載のアダプティブアレーアンテナ。

【請求項15】 複数のアンテナ素子(11～14)と、
前記複数のアンテナ素子で受信された受信信号にそれぞれのアンテナウエイトを乗算するアンテナ乗算手段(21…24)と、
前記アンテナウエイトが乗算されたそれぞれの受信信号を加算して加算信号を出力する加算手段(30)と、
前記複数のアンテナ素子で受信された受信信号のうち、これら受信信号の周波数帯域に比べて狭い周波数帯域の成分を示す受信周波数信号をそれぞれ出力する受信周波数信号出力手段(420～423)と、
既知信号のうち、前記狭い周波数帯域の成分を示す既知周波数信号を出力する既知周波数信号出力手段(424)と、
前記既知周波数信号に対して所定期間遅延した遅延周波

数信号を求める遅延手段(80A)と、

前記遅延周波数信号及び前記既知周波数信号に信号ウエイトを乗算して参照信号を求める参照信号算出手段(53A)と、

前記参照信号と前記加算信号とを加算して加算参照信号を求める加算参照信号算出手段(51A)と、

前記加算参照信号のうち、前記遅延周波数信号及び前記既知周波数信号を除く成分の電力を小さくするように前記アンテナウエイト及び前記信号ウエイトを更新する更新手段(41)とを有することを特徴とするアダプティブアレーアンテナ。

【請求項16】 複数のアンテナ素子(11、12)と、

前記複数のアンテナ素子で受信された受信OFDM信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段(801、802)と、

前記周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段(201、202)と、

20 前記アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段(300)と、
既知OFDM信号を周波数弁別して既知弁別信号を求める既知周波数分別手段(83)と、

前記既知弁別信号に対してそれぞれの位相量だけ位相回転して、前記それぞれの位相量に対応する位相回転既知弁別信号を求める位相回転手段(1000)と、

前記それぞれの位相量に対応する位相回転既知弁別信号と前記それぞれの弁別信号との相関をとって、前記それぞれの位相量に対応する相関値を求める相関手段(1010)と、

30 前記それぞれの位相量に対応する相関値のうち、最大相関値を選択するとともに、前記それぞれの位相量に対応する位相回転既知弁別信号うち、前記最大相関値に対応する対応位相回転既知弁別信号を選択する選択手段(1020)と、

前記加算信号のうち、前記それぞれの位相量に対応する位相回転既知弁別信号を除く成分を小さくするとともに、前記加算信号のうち、前記対応位相回転既知弁別信号を少なくとも残すように前記アンテナウエイトを更新する更新手段(1034)とを有することを特徴とするアダプティブアレーアンテナ。

【請求項17】 複数のアンテナ素子(11、12)と、

前記複数のアンテナ素子で受信された受信OFDM信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段(801、802)と、

前記周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段(201、202)と、

50 前記アンテナウエイトが乗算されたそれぞれの弁別信号

を加算して加算信号を出力する加算手段(300)と、
 前記それぞれの弁別信号のうち、前記弁別信号に比べて
 狭い周波数帯域の狭帯域弁別信号をそれぞれ出力する狭
 帯域出力手段(1040)と、
 既知OFDM信号を周波数弁別して既知弁別信号を求め
 る所望周波数分別手段(83)と、
 前記既知弁別信号のうち、前記既知弁別信号に比べて狭
 い周波数帯域の狭帯域既知弁別信号を出力する既知狭帯
 域出力手段(1041)と、
 前記狭帯域既知弁別信号に対してそれぞれ異なる位相量
 だけ位相回転して、前記それぞれの位相量に対応する狭
 帯域の位相回転弁別信号を求める位相回転手段(100
 0)と、
 前記それぞれの位相量に対応する狭帯域の位相回転弁別
 信号と前記それぞれの弁別信号との相関をとって、前記
 それぞれの位相量に対応する相関値を求める相関手段
 (1010)と、
 前記それぞれの位相量に対応する相関値のうち、最大相
 関値を選択するとともに、前記それぞれの狭帯域の位相
 回転弁別信号のうち、前記最大相関値に対応する狭帯域
 の位相回転弁別信号を選択する選択手段(1020)
 と、
 前記加算信号のうち、前記それぞれの位相量に対応する
 狭帯域の位相回転既知弁別信号を除く成分を小さくする
 とともに、前記加算信号のうち、前記対応する狭帯域の
 位相回転弁別信号を少なくとも残すように前記アンテナ
 ウェイトを更新する更新手段(1033)とを有すること
 を特徴とするアダプティブアレーアンテナ。
 【請求項18】 複数のアンテナ素子(11、12)
 と、
 前記複数のアンテナ素子で受信された受信OFDM信号
 をそれぞれ周波数弁別して弁別信号を求める受信周波数
 弁別手段(801、802)と、
 前記周波数弁別されたそれぞれの弁別信号にアンテナウ
 ェイトを乗算するアンテナ乗算手段(201、202)
 と、
 前記アンテナウェイトが乗算されたそれぞれの弁別信号
 を加算して加算信号を出力する加算手段(300)と、
 前記それぞれの弁別信号のうち、前記弁別信号に比べて
 狭い周波数帯域の狭帯域弁別信号をそれぞれ出力する狭
 帯域出力手段(1040)と、
 既知OFDM信号を周波数弁別して既知弁別信号を求め
 る所望周波数分別手段(83)と、
 前記既知弁別信号のうち、前記既知弁別信号に比べて狭
 い周波数帯域の狭帯域既知弁別信号を出力する既知狭帯
 域出力手段(1041)と、
 前記狭帯域既知弁別信号を位相回転する位相回転手段
 (1000)と、前記加算信号のうち、前記狭帯域既知
 弁別信号と前記位相回転された狭帯域既
 知弁別信号とを除く成分の電力を小さくするように前記

アンテナウェイトを更新する更新手段(1030A)と
 を有することを特徴とするアダプティブアレーアンテ
 ナ。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、アダプティブアレ
 ーアンテナに関する。

【0002】

【従来の技術】近年、直交マルチキャリア方式の受信信
 号を受信するMMSE方式のアダプティブアレーアンテ
 ナが各種提案されている。まず、直交マルチキャリア方
 式の信号(以下、直交マルチキャリア方式の信号をOF
 DM信号という)の概略について図25、図26を参照
 して説明する。

【0003】図25に示すように、OFDM信号は、デ
 ータ信号とこのデータ信号に先立つプリアンプル信号と
 から構成されている。プリアンプル信号は、周波数軸上
 に複数のパイロットシンボル(既知信号)を配列した信
 号である。データ信号は、時間多重された複数のOFDM
 シンボルからなり、OFDMシンボルは、有効シンボ
 ルとこの有効シンボルに先だつガードインターバルGI
 とからなる。

【0004】ガードインターバルGIは、有効シンボル
 うち、後側の所定期間部分を複製したものである。従っ
 て、図26に示すように、所望のOFDM信号とその遅
 延信号との和を受信信号として受信されたとき、所望の
 OFDM信号に対する遅延信号の遅延時間がガードイン
 ターバルGIの期間TGより短ければ、受信信号をFFT
 処理(周波数弁別処理)によって、データ(例えばQ
 PSKシンボル)が復元可能である。

【0005】次に、MMSE(Minimum Mean Square Error)方式のアダプ
 ティブアレーアンテナについて図23を参照して説明す
 る。図27は、MMSE方式のアダプティブアレーアン
 テナの概略構成を示す。MMSE方式のアダプティブア
 レーアンテナは、アンテナ素子11...1M、乗算器21
 ...2M、加算器(Σ)30、MMSE演算器40、加算
 器50、及び、発生器60から構成されている。なお、
 Mは、自然数である。

【0006】アンテナ素子11...1Mは、それぞれ、電
 波を媒体としてOFDM信号を受信して、受信OFDM
 信号 $X(i)$ を出力する。ここで、受信OFDM信号 X
 (i) は、数式1で表すことができる。Tは転置を示
 す。iは時刻を示す。

【0007】

【数1】

$$X(i) = [x_1(i) \quad x_2(i) \quad \cdots \quad x_M(i)]^T$$

 このため、アンテナ素子11...1Mは、それぞれ、受信
 OFDM信号 $x_1(i)$ 、 $x_2(i)$ 、... $x_M(i)$ を出
 力する。また、MMSE演算器50は、乗算器21、2

2...2Mのそれぞれにアンテナウエイト W に乗算する。

【0008】ここで、アンテナウエイト W を数式2で表すことができる。 H は複素共役転置である。

【0009】

【数2】 $W = [w_1 \ w_2 \ \dots \ w_M]^T$

具体的には、乗算器20は、アンテナウエイト w_1^* に受信OFDM信号 $x_1(i)$ を乗算して乗算信号 $(w_1^* x_1(i))$ を出力し、乗算器21は、アンテナウエイト w_2^* に受信OFDM信号 $x_2(i)$ を乗算して乗算信号 $(w_2^* x_2(i))$ を出力する。乗算器2Mは、アンテナウエイト w_M^* に受信OFDM信号 $x_M(i)$ を乗算して乗算信号 $(w_M^* x_M(i))$ を出力する。

【0010】加算器(Σ)30は、乗算信号 $(w_1^* x_1(i))$ 、乗算信号 $(w_2^* x_2(i))$...乗算信号 $(w_M^* x_M(i))$ を加算することにより、アンテナウエイト W と受信OFDM信号 $X(i)$ との内積を示す内積信号 $W^H X(i)$ を求める。発生器60は、参照信号 $r_0(i)$ を予め記憶したこの参照信号 $r_0(i)$ を加算器50に出力し、加算器50は、参照信号 $r_0(i)$ と内積信号 $W^H X(i)$ との誤差 $e(i)$ を求める $\{e(i) = r_0(i) - W^H X(i)\}$ 。MMSE演算器40は、受信OFDM信号 $X(i)$ 及び誤差 $e(i)$ を入力として、この誤差 $e(i)$ を小さくするようにアンテナウエイト W を更新してそのアンテナウエイト W を乗算器21、22...2Mに出力する。

【0011】ここで、参照信号 $r_0(i)$ として所望既知信号(例えば、時間軸上のプリアンプル信号)を採用することにより、受信OFDM信号 $X(i)$ のうち、所望既知信号を除く遅延信号等を抑圧することができる。因みに、MMSE方式のアダプティブアレーアンテナにおいて、抑圧可能な既知信号(ヌル点)の数は、アンテナ素子の数により規定されて、(アンテナ素子数) - 「1」である。以下、抑圧可能な既知信号(ヌル点)の数を自由度という。

【0012】

【発明が解決しようとする課題】ところで、MMSE方式のアダプティブアレーアンテナでは、上述の如く、所望既知信号とその遅延信号との和を受信信号として受信したとき、所望既知信号に対する遅延信号の遅延時間が、ガードインターバル $G1$ の期間 TG より短ければ、受信信号からデータ(図26中のデータ1~データ4)を復元可能であるにも関わらず、当該遅延信号(以下、 $G1$ 内遅延信号という)を抑圧することになる。

【0013】このように、抑圧する必要が無く、且つ、復元して合成することが可能な $G1$ 内遅延信号をも抑圧することにより、複数の信号を合成して受信性能を向上させることができなくなる。

【0014】また、 $G1$ 内遅延信号を抑圧するために、アダプティブアレーアンテナにおけるヌル点を形成する

ことになるため、 $G1$ 内遅延信号より遅延した遅延信号のように、本来ヌル点を形成すべき信号にヌル点を形成できなくなるという問題がある。すなわち、アダプティブアレーアンテナの自由度を無駄に消費することになる。

【0015】本発明は、上記に鑑み、自由度の無駄な消費を抑えるようにしたアダプティブアレーアンテナを提供することを目的とする。

【0016】

10 【課題を解決するための手段】本発明は、上記目的を達成するために、請求項1に記載の発明では、複数のアンテナ素子(11...1M)と、複数のアンテナ素子で受信された受信信号にそれぞれのアンテナウエイトを乗算するアンテナ乗算手段(21...2M)と、アンテナウエイトが乗算されたそれぞれの受信信号を加算して加算信号を出力する加算手段(30)と、第1の既知信号及び第2の既知信号から参照信号を求める参照算出手段(51~53、51A、53A)と、複数のアンテナ素子で受信された受信信号と参照信号と加算信号とに応じてアンテナウエイトを更新する更新手段(40A、41)とを備えることを特徴とする。

20 【0017】ここで、参照信号は、第1及び第2の既知信号から算出されるもので、更新手段は、当該参照信号と上記受信信号と第2の既知信号と加算信号とに応じてアンテナウエイトを更新する。このため、更新手段は、アンテナウエイトの更新によって、複数のアンテナ素子で受信された受信信号のうち、第1及び第2の既知信号を除く成分を抑圧し得る。従って、第2の既知信号の抑圧が防止されるため、第2の既知信号の抑圧が無用である場合、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。このため、アダプティブアレーアンテナの自由度の無駄な消費を抑える。

30 【0018】また、受信信号のうち第1及び第2の既知信号を除く成分を抑圧するため、受信信号のうち、第1及び第2の既知信号の合成信号を得ることができる。ここで、請求項2に記載の発明のように、第2の既知信号は、前記第1の既知信号に対して所定期間遅延した遅延信号であるとき、第1の既知信号だけを復調する場合に比べて、第1及び第2の既知信号の合成信号を用いて復調する場合には、良好な復調信号を得られる。

40 【0019】さらに、請求項3に記載の発明のように、第1の既知信号を所定期間遅延させて第2の既知信号を求める遅延手段(80)を有するようにしてもよい。また、第2の既知信号を予め用意するのではなく、第2の既知信号を受信信号に応じて求めるようにしてもよい。

50 【0020】すなわち、請求項4に記載の発明のように、複数のアンテナ素子は、それぞれ、第1の既知信号の成分と第2の既知信号の成分とを有する信号を受信信号として受信し、複数のアンテナ素子で受信された受信

信号に基づいて、第1の既知信号の成分に対する第2の既知信号の成分の遅延時間を求める遅延時間算出手段(100)を有し、遅延手段は、所望既知信号を遅延時間だけ遅延させて第2の既知信号を求めるようにしてもよい。

【0021】さらに、請求項5に記載の発明のように、第1の既知信号に対してそれぞれ異なる時間だけ遅延した複数の遅延信号を生成する遅延信号生成手段(90)と、遅延信号生成手段の各遅延信号と前記受信信号との相関検出を行う相関検出器(131a~134c)と、相関検出器の相関検出に基づいて複数の遅延信号の何れかを第2の既知信号として選択する選択手段(135a~136)とを有するようにしてもよい。

【0022】具体的には、請求項6に記載の発明のように、参照信号算出手段は、第2の既知信号に信号ウェイトを乗算して、この信号ウェイトが乗算された第2の既知信号に第1の既知信号を加算して参照信号を求め、更新手段は、複数のアンテナ素子で受信された受信信号と第2の既知信号と参照信号とを加算信号とに応じて信号ウェイトを更新するようにしてもよい。

【0023】ここで、請求項7に記載の発明では、加算手段の加算信号のうち第2の既知信号の成分を抑圧するために帰還信号を加算する抑圧手段(129、130)と、加算信号を所定期間だけ遅延させて遅延加算信号を生成する加算信号遅延手段(121~124)と、遅延加算信号に前記信号ウェイトを乗算して前記帰還信号を求める乗算手段(125~128)とを有することを特徴とする。これにより、抑圧手段は、加算信号のうち第2既知信号の成分を抑圧して第1の既知信号の成分だけを出力できる。

【0024】請求項8に記載の発明では、複数のアンテナ素子(11...1M)と、複数のアンテナ素子で受信された受信OFDM信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段(801~80M)と、周波数弁別されたそれぞれの弁別信号にアンテナウェイトを乗算するアンテナ乗算手段(201~20M)と、アンテナウェイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段(300)と、所望OFDM信号が周波数弁別された所望弁別信号を求める所望周波数分別手段(84)と、所望弁別信号に対して遅延した遅延弁別信号を求める遅延手段(90、83)と、遅延弁別信号に信号ウェイトを乗算して、この信号ウェイトが乗算された遅延弁別信号に所望弁別信号を加算して参照信号を求める参照加算手段(510、520、530)と、前記それぞれの弁別信号と前記遅延弁別信号とに応じて前記参照信号に前記加算信号を近づけるようにして、前記それぞれの弁別信号のうち前記所望弁別信号及び遅延弁別信号の双方を除く成分を抑圧するように前記アンテナウェイト及び前記信号ウェイトを更新する更新手段(40B)とを備えることを特徴とす

る。

【0025】このように、更新手段は、それぞれの弁別信号のうち所望弁別信号及び遅延弁別信号の双方を除く成分を抑圧するようにアンテナウェイト及び信号ウェイトを更新する。このため、遅延弁別信号の抑圧が防止されるため、遅延弁別信号の抑圧が無用であるとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。このため、アダプティブアレーアンテナの自由度の無駄な消費を抑える。

【0026】また、更新手段は、上述の如く、それぞれの弁別信号のうち所望弁別信号及び遅延弁別信号の双方を除く成分を抑圧するようにアンテナウェイト及び信号ウェイトを更新するため、それぞれの弁別信号のうち所望弁別信号及び遅延弁別信号の双方を得られる。このような所望弁別信号及び遅延弁別信号の双方を用いて復調すれば、所望弁別信号だけで復調する場合に比べて、良好な復調信号が得られる。

【0027】請求項9に記載の発明では、複数のアンテナ素子(11~14)と、前記複数のアンテナ素子で受信された受信OFDM信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段(801~804)と、前記周波数弁別されたそれぞれの弁別信号にアンテナウェイトを乗算するアンテナ乗算手段(201~204)と、前記アンテナウェイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段(300)と、所望OFDM信号に対して所定期間遅延した遅延OFDM信号を求める遅延手段(80A)と、前記所望OFDM信号及び前記遅延OFDM信号の双方が周波数弁別された所望弁別信号を求める所望周波数分別手段(834)と、前記所望弁別信号に信号ウェイトを乗算して参照信号を求める参照加算手段(530A)と、前記参照信号と前記加算信号とを加算して加算参照信号を求める加算参照信号算出手段(510A)と、前記加算参照信号のうち、前記所望弁別信号を除く成分の電力を小さくするように前記アンテナウェイト及び前記信号ウェイトを更新する更新手段(42)とを備えることを特徴とする。

【0028】このように、更新手段は加算参照信号のうち所望弁別信号をの成分を除く成分の電力を小さくするようにアンテナウェイト及び信号ウェイトを更新するため、加算参照信号のうち所望弁別信号の成分を除く成分の電力を小さくできる。従って、所望弁別信号の抑圧が防止される、すなわち、所望OFDM信号が周波数弁別された信号の抑圧が防止されるとともに、遅延OFDM信号が周波数弁別された信号の抑圧が防止される。

【0029】このため、遅延OFDM信号が周波数弁別された信号の抑圧が無用である場合、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。このため、アダプティブアレー

アンテナの自由度の無駄な消費を抑える。

【0030】また、請求項10に記載の発明のように、既知信号が周波数軸上に配列されたブリアンブル信号を、前記所望OFDM信号として生成する生成手段(60)を有するようにしてもよい。さらに、請求項11に記載の発明のように、受信周波数弁別手段は、受信OFDM信号をサンプリングして各サンプリング信号を得て、各サンプリング信号に応じて前記弁別信号を求め、遅延時間は、サンプリングの周期の所定倍数であるようにしてもよい。

【0031】さらに、請求項12に記載の発明では、遅延手段は、1つの遅延弁別信号だけに限らず、所望個数の前記遅延弁別信号を出力することを特徴とする。これにより、更新手段は、請求項1に記載の発明と同様に、前記それぞれの弁別信号のうち前記所望弁別信号及び所望個数の遅延弁別信号を除く成分を抑圧するように前記それぞれのアンテナウエイト及び信号ウエイトを更新することができる。

【0032】さらに、請求項13に記載の発明では、遅延弁別信号の所望個数は、所望OFDM信号のデータ信号のガードインターバル期間と、サンプリングの周期とによって決まる最大個数であることを特徴とする。これにより、より、一層、数多くの遅延弁別信号の抑圧を防止できるため、アダプティブアレーアンテナの自由度の無駄な消費を、効果的に、抑えることができる。なお、遅延弁別信号の最大個数は、{(ガードインターバル期間/サンプリングの周期)-1}である。

【0033】請求項14に記載の発明では、参照信号算出手段は、前記第1及び第2の既知信号に信号ウエイトを乗算して前記参照信号を求める手段(53A)と、前記参照信号と前記加算信号とを加算して加算参照信号を求める手段(51A)とを有し、前記更新手段(41)は、前記加算参照信号のうち、前記第1及び第2の既知信号を除く成分の電力を小さくするように前記アンテナウエイト及び前記信号ウエイトを更新することを特徴とする。

【0034】このように、更新手段(41)は、加算参照信号のうち、第1及び第2の既知信号を除く成分の電力を小さくするようにアンテナウエイト及び信号ウエイトを更新するため、加算参照信号のうち、第1及び第2の既知信号を除く成分の電力を小さくできる。このため、第1及び第2の既知信号の抑制を防止でき、第2の既知信号の抑制が無用のとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効に行うことができる。

【0035】請求項15に記載の発明では、複数のアンテナ素子(11~14)と、前記複数のアンテナ素子で受信された受信信号にそれぞれのアンテナウエイトを乗算するアンテナ乗算手段(21~24)と、前記アンテナウエイトが乗算されたそれぞれの受信信号を加算して

加算信号を出力する加算手段(30)と、前記複数のアンテナ素子で受信された受信信号のうち、これら受信信号の周波数帯域に比べて狭い周波数帯域の成分を示す受信周波数信号をそれぞれ出力する受信周波数信号出力手段(420~423)と、既知信号のうち、前記狭い周波数帯域の成分を示す既知周波数信号を出力する既知周波数信号出力手段(424)と、前記既知周波数信号に対して所定期間遅延した遅延周波数信号を求める遅延手段(80A)と、前記遅延周波数信号及び前記既知周波数信号に信号ウエイトを乗算して参照信号を求める参照信号算出手段(53A)と、前記参照信号と前記加算信号とを加算して加算参照信号を求める加算参照信号算出手段(51A)と、前記加算参照信号のうち、前記遅延周波数信号及び前記既知周波数信号を除く成分の電力を小さくするように前記アンテナウエイト及び前記信号ウエイトを更新する更新手段(41)とを有することを特徴とする。

【0036】このように、更新手段は、加算参照信号のうち、遅延周波数信号及び既知周波数信号を除く成分の電力を小さくするようにアンテナウエイト及び信号ウエイトを更新するため、加算参照信号のうち、遅延周波数信号及び既知周波数信号を除く成分の電力を小さくできる。このため、遅延周波数信号及び既知周波数信号の抑制を防止でき、遅延周波数信号の抑制が無用のとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効に行うことができる。

【0037】ここで、アンテナウエイト及び信号ウエイトの更新回数は、受信信号の周波数帯域によって決まり、上述の如く、アンテナウエイト及び信号ウエイトの更新にあたり、受信信号に代えて、受信信号の周波数帯域に比べて狭い周波数帯域の既知周波数信号を用いているため、アンテナウエイト及び信号ウエイトの更新回数を減らすことができる。

【0038】また、請求項16に記載の発明では、複数のアンテナ素子(11、12)と、複数のアンテナ素子で受信された受信OFDM信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段(801、802)と、周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段(201、202)と、アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段(300)と、既知OFDM信号を周波数弁別して既知弁別信号を求める既知周波数分別手段(83)と、既知弁別信号に対してそれぞれの位相量だけ位相回転して、それぞれの位相量に対応する位相回転既知弁別信号を求める位相回転手段(1000)と、それぞれの位相量に対応する位相回転既知弁別信号とそれぞれの弁別信号との相関をとって、それぞれの位相量に対応する相関値を求める相関手段(1010)と、それぞれの位相量に対応する相関値のうち、最大相関値を選択するとともに、それぞれの

位相量に対応する位相回転既知弁別信号うち、最大相関値に対応する対応位相回転既知弁別信号を選択する選択手段(1020)と、加算信号のうち、それぞれの位相量に対応する位相回転既知弁別信号を除く成分を小さくするとともに、加算信号のうち、対応位相回転既知弁別信号を少なくとも残すようにアンテナウエイトを更新する更新手段(1034)とを有することを特徴とする。

【0039】このように、更新手段は、加算信号のうち、それぞれの位相量に対応する位相回転既知弁別信号を除く成分を小さくするアンテナウエイトを更新する。従って、加算信号のうち、それぞれの位相量に対応する位相回転既知弁別信号を除く成分を小さくできる。このため、それぞれの位相量に対応する位相回転既知弁別信号の抑制を防止でき、それぞれの位相量に対応する位相回転既知弁別信号の抑制が無用のとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。

【0040】さらに、更新手段は、加算信号のうち、最大相関値に対応する対応位相回転既知弁別信号を少なくとも残すようにアンテナウエイトを更新する。従って、加算信号のうち、最大相関値に対応する対応位相回転既知弁別信号を少なくとも残すことができる。

【0041】ここで、対応位相回転既知弁別信号は、それぞれの位相量に対応する位相回転既知弁別信号のうち、最大電力値の位相回転既知弁別信号に対応するため、対応位相回転既知弁別信号を残すことにより、受信電力値の大きな回転既知弁別信号を得ることができる。

【0042】請求項17に記載の発明では、複数のアンテナ素子(11、12)と、複数のアンテナ素子で受信された受信OFDM信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段(801、802)と、周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段(201、202)と、アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段(300)と、それぞれの弁別信号のうち、弁別信号に比べて狭い周波数帯域の狭帯域弁別信号をそれぞれ出力する狭帯域出力手段(1040)と、既知OFDM信号を周波数弁別して既知弁別信号を求める所望周波数分別手段(83)と、既知弁別信号のうち、既知弁別信号に比べて狭い周波数帯域の狭帯域既知弁別信号を出力する既知狭帯域出力手段(1041)と、狭帯域既知弁別信号に対してそれぞれ異なる位相量だけ位相回転して、それぞれの位相量に対応する狭帯域の位相回転弁別信号を求める位相回転手段(1000)と、それぞれの位相量に対応する狭帯域の位相回転弁別信号とそれぞれの弁別信号との相関をとって、それぞれの位相量に対応する相関値を求める相関手段(1010)と、それぞれの位相量に対応する相関値のうち、最大相関値を選択するとともに、それぞれの狭帯域の位相回転弁別信号のうち、最大相関値に

応する狭帯域の位相回転弁別信号を選択する選択手段(1020)と、加算信号のうち、それぞれの位相量に対応する狭帯域の位相回転既知弁別信号を除く成分を小さくするとともに、加算信号のうち、対応する狭帯域の位相回転弁別信号を少なくとも残すように更新する更新手段(1033)とを有することを特徴とする。

【0043】このように、更新手段は、加算信号のうち、それぞれの位相量に対応する狭帯域の位相回転既知弁別信号を除く成分を小さくするアンテナウエイトを更新するため、加算信号のうち、それぞれの位相量に対応する狭帯域の位相回転既知弁別信号を除く成分を小さくできる。このため、それぞれの位相量に対応する狭帯域の位相回転既知弁別信号の抑制を防止でき、それぞれの位相量に対応する狭帯域の位相回転既知弁別信号の抑制が無用のとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。

【0044】さらに、更新手段は、加算信号のうち、最大相関値に対応する狭帯域の位相回転既知弁別信号を少なくとも残すようにアンテナウエイトを更新する。従って、加算信号のうち、最大相関値に対応する狭帯域の位相回転既知弁別信号を少なくとも残すことができる。

【0045】ここで、前記対応する狭帯域の位相回転既知弁別信号は、それぞれの位相量に対応する位相回転既知弁別信号のうち、最大電力値の位相回転既知弁別信号に対応するため、前記対応する狭帯域の位相回転既知弁別信号を残すことにより、受信電力値の大きな回転既知弁別信号を得ることができる。

【0046】ここで、更新手段がアンテナウエイトを更新するにあたり、狭帯域の位相回転弁別信号を用いているため、請求項16に記載の発明に比べて、更新のための演算量を減らすことができる。

【0047】請求項18に記載の発明では、複数のアンテナ素子(11、12)と、複数のアンテナ素子で受信された受信OFDM信号をそれぞれ周波数弁別して弁別信号を求める受信周波数弁別手段(801、802)と、周波数弁別されたそれぞれの弁別信号にアンテナウエイトを乗算するアンテナ乗算手段(201、202)と、アンテナウエイトが乗算されたそれぞれの弁別信号を加算して加算信号を出力する加算手段(300)と、それぞれの弁別信号のうち、弁別信号に比べて狭い周波数帯域の狭帯域弁別信号をそれぞれ出力する狭帯域出力手段(1040)と、既知OFDM信号を周波数弁別して既知弁別信号を求める所望周波数分別手段(83)と、既知弁別信号のうち、既知弁別信号に比べて狭い周波数帯域の狭帯域既知弁別信号を出力する既知狭帯域出力手段(1041)と、狭帯域既知弁別信号を位相回転する位相回転手段(1000)と、加算信号のうち、狭帯域既知弁別信号と前記位相回転された狭帯域既知弁別信号とを除く成分の電力を小さくするようにアンテナウ

エイトを更新する更新手段(1030A)とを有することとを特徴とする。

【0048】このように、加算信号のうち、狭帯域既知弁別信号と位相回転された狭帯域既知弁別信号とを除く成分の電力を小さくするようにアンテナウエイトを更新するため、加算信号のうち、狭帯域既知弁別信号と前記位相回転された狭帯域既知弁別信号を除く成分の電力を小さくできる。このため、狭帯域既知弁別信号と前記位相回転された狭帯域既知弁別信号の抑制を防止でき、狭帯域既知弁別信号と前記位相回転された狭帯域既知弁別信号の抑制が無用のとき、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。

【0049】ここで、更新手段がアンテナウエイトを算出するにあたり、前記位相回転された狭帯域既知弁別信号と狭帯域の位相回転弁別信号を用いているため、更新のための演算量を減らすことができる。

【0050】因みに、上記各手段の括弧内の符号は、後述する実施形態に記載の具体的手段との対応関係を示す一例である。

【0051】

【発明の実施の形態】(第1実施形態)図1に、本発明の第1実施形態に係るMMSE方式のアダプティブアレーアンテナを示す。本第1実施形態においては、MMSE方式のアダプティブアレーアンテナが、OFDM信号を受信する例を示す。図1は、MMSE方式のアダプティブアレーアンテナの概略構成をブロック図である。MMSE方式のアダプティブアレーアンテナは、図1に示すように、アンテナ素子11...1M(Mは自然数)、乗算器21...2M、加算器(Σ)30、MMSE演算器40A、加算器51、52、乗算器53、及び発生器60、70から構成されている。図1において、図18中の符号と同一符号は、同一物、或いは、実質的同一物を示す。

【0052】発生器60は、所望既知信号として、OFDM信号のプリアンブル信号 $r_0(i)$ を発生し、このプリアンブル信号 $r_0(i)$ は、周波数軸上に複数のパイロットシンボル(既知信号)が配列された信号である。

【0053】発生器70は、プリアンブル信号 $r_0(i)$ に対するU(Uは自然数)個の遅延信号を、他の既知信号として、発生して、U個の遅延信号は、それぞれ、プリアンブル信号に対して異なる遅延時間を有する。但し、プリアンブル信号に対するU個の遅延信号のそれぞれの遅延時間は、OFDMシンボルのガードインターバルGIの期間TGに比べて短く、以下、U個の遅延信号を、数式3に示す遅延信号 $R(i)$ とする。

【0054】

【数3】

$$R(i) = [r_1(i) \quad r_2(i) \quad \dots r_U(i)]^T$$

次に、乗算器53は、数式4に表す信号ウエイト A^H を遅延信号 $R(i)$ に乗算して数式5に示す乗算信号 $\{A^H R(i)\}$ を出力する。

【0055】

$$【数4】 A = [a_1 \quad a_2 \quad \dots a_U]^T$$

【0056】

$$【数5】 A^H R(i) = a_1^* r_1(i) + a_2^* r_2(i) + \dots a_U^* r_U(i)$$

次に、加算器52は、プリアンブル信号 $r_0(i)$ と乗算信号 $A^H R(i)$ とを加算して加算信号 $(r_0(i) + A^H R(i))$ を出力する。ここで、加算信号 $(r_0(i) + A^H R(i))$ は、プリアンブル信号 $r_0(i)$ と遅延信号 $R(i)$ との合成信号(参照信号)になる。そして、加算器51は、加算信号 $(r_0(i) + A^H R(i))$ と加算器30の内積信号 $W^H X(i)$ との誤差 $e(i)$ を求める。ここで、誤差 $e(i)$ を数式6に表すことができる。

【0057】

$$【数6】 e(i) = r_0(i) + A^H R(i) - W^H X$$

次に、MMSE演算器40Aには、受信OFDM信号 $X(i)$ 、遅延信号 $R(i)$ 、及び、誤差 $e(i)$ が入力されて、MMSE演算器40Aは、例えば、MMSE方式のSMI(Sample Matrix Inversion)法に基づいて誤差 $e(i)$ を小さくするようにアンテナウエイト W を更新して乗算器21、22...2Mに出力するとともに、MMSE方式のSMI法に基づいて誤差 $e(i)$ を小さくするように信号ウエイト A を更新して乗算器53に出力する。

【0058】これにより、加算器30の内積信号 $W^H X$ としては、受信OFDM信号 $X(i)$ のうちプリアンブル信号 $r_0(i)$ (所望既知信号)と遅延信号 $R(i)$ (他の既知信号)とを除く成分が抑圧された信号になる。

【0059】ここで、信号ウエイト A は、MMSE演算器40Aによって、プリアンブル信号 $r_0(i)$ (第1の既知信号)を基準とした遅延信号 $R(i)$ (第2の既知信号)の位相差及び振幅差を示すように求められる。

【0060】以下、本第1実施形態の特徴について述べる。まず、プリアンブル信号 r_0 に対する遅延信号 $R(i)$ の遅延時間は、上述の如く、ガードインターバルGIの期間TGに比べて短いため、受信OFDM信号 $X(i)$ のうち遅延信号 $R(i)$ を抑圧することなく、加算器30の内積信号 $W^H X$ をFFT処理(周波数弁別)によってデータ(例えば、QPSKデータシンボル)を復元できる。

【0061】すなわち、受信OFDM信号 $X(i)$ のうち遅延信号 $R(i)$ の抑圧が無用である。そこで、本第1実施形態では、上述の如く、加算器30の内積信号 $W^H X$ として、受信OFDM信号 $X(i)$ のうちプリアンブル信号 $r_0(i)$ と遅延信号 $A^H R(i)$ とを除く成分

が抑圧された信号が得られる。

【0062】このため、遅延信号 $R(i)$ の抑圧が防止されるため、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。従って、MMSE方式のアダプティブアレーアンテナの自由度の無駄な消費を抑え得る。

【0063】また、加算器30の内積信号 $W^H X$ として、プリアンブル信号 $r_0(i)$ と遅延信号 $R(i)$ との加算信号 $(r_0(i) + A^H R(i))$ が得られるため、この加算信号を復調すれば、プリアンブル信号 $r_0(i)$ だけを復調する場合に比べて、良好な復調信号が得られる。

【0064】ここで、図2において、シュミレーションの結果を示す。図2中、横軸は、MMSE方式のアダプティブアレーアンテナを基準とした受信電波の受信角度[deg]で、縦軸は、抑圧比(dB)である。鎖線は、従来のMMSE方式のアダプティブアレーアンテナを用いたシュミレーションの結果を示す。実線は、本第1実施形態のMMSE方式のアダプティブアレーアンテナを用いたシュミレーションの結果を示す。

【0065】図2から分かるように、従来のMMSE方式のアダプティブアレーアンテナでは、GI内遅延信号が抑圧されているが、本第1実施形態のMMSE方式のアダプティブアレーアンテナでは、GI内遅延信号の抑圧が防止されている。但し、GI内遅延信号は、所望信号(プリアンブル信号 r_0)に対して(ガードインターバルGI)の期間TGに比べて短い遅延時間を有する遅延信号である。

【0066】以下に、本第1実施形態でのMMSE演算器40AのMMSE方式のSMIアルゴリズムについて述べる。まず、数式6に示す誤差 $e(i)$ を変形して、誤差 $e(i)$ を、数式7のように表すことができる。

【0067】

【数7】

$$\begin{aligned} e(i) &= r_0(i) + R(i) A^H - W^H X \\ &= r_0(i) - \{W^H X - R(i) A^H\} \\ &= r_0(i) - Y^H Z(i) \end{aligned}$$

ここで、 Y は、数式8に示すようにアンテナウエイト W 、及び、信号ウエイト A の双方を含めたウエイトで、 $Z(i)$ は、数式9に表すように、受信OFDM信号 $X(i)$ 及び遅延信号 $R(i)$ の双方を含めた信号である。

【0068】

【数8】 $Y = [w_1 \ w_2 \ w_3 \ \dots \ w_M \ -a_1 \ -a_2 \ -a_3 \ \dots \ -a_U]^T$

【0069】

【数9】 $Z = [x_1(i) \ x_2(i) \ x_3(i) \ \dots \ x_M(i) \ r_1(i) \ r_2(i) \ r_3(i) \ \dots \ r_U(i)]^T$ SMI

アルゴリズムにおいては、数式10に示す評価関数 Q を直

接最小化する。但し、 α は、 $0 < \alpha \leq 1$ の重み付け定数である。

【0070】

【数10】

$$Q(i) = \sum_{l=1}^G \alpha^{G-l} |e(i)|^2$$

【0071】さらに、数式7のウエイト Y に関する勾配ベクトルをゼロとにおいて、評価関数 Q の最小二乗が数式11のように得られる。この数式11は、ウエイト $Y(G)$ を更新するための式を示す。但し、 G は、時間(サンプリング時間)であって、 G は、ウエイト Y の更新回数(ステップ数)を示す。

【0072】

【数11】

$$Y(G) = B^{-1}(G) b(G)$$

【0073】ここで、数式11中の B 、 b を数式12、数式13を示す。

【0074】

【数12】

$$B = \sum_{l=1}^G \alpha^{G-l} Z(i) Z^H(i)$$

【0075】

【数13】

$$b(G) = \sum_{l=1}^G \alpha^{G-l} Z(i) r_0^*(i)$$

【0076】(第2実施形態) 上記第1実施形態では、遅延信号 $R(i)$ (U 個の遅延信号)を発生させるために発生器70を採用した例について説明したが、これに限らず、発生器60から出力されたプリアンブル信号を用いて遅延信号 $R(i)$ を発生させるようにしてもよい。この場合の構成を図3、図4に示す。

【0077】図3は、本第2実施形態のMMSE方式のアダプティブアレーアンテナの構成を示すブロック図で、図4は、図3中の遅延回路(以下、遅延回路80という)の詳細を示す図である。本第2実施形態では、図3に示すように、図1に示す発生器60が削除されるとともに、遅延回路80が採用されている。図3において、図1中の符号と同一符号は、同一物、或いは、実質的同一物を示す。

【0078】遅延回路80は、発生器60と乗算器53との間に配置されたものであって、発生器60から出力されたプリアンブル信号を受けて、上記第1実施形態で述べた遅延信号 $R(i)$ を出力する。

【0079】具体的には、遅延回路80は、図4に示すように、遅延器(Z^{-1})801、802、803、...80Uを直列接続して構成されており、遅延器801、802、803、...80Uは、それぞれ対応する遅延信号 $r_1(i)$ 、 $r_2(i)$ 、... $r_U(i)$ をMMSE演算器40A及び乗算器53に出力する。その他の作動、

効果は、上記第1実施形態と同様である。

【0080】(第3実施形態)上記第1、第2実施形態では、MMSE方式のアダプティブアレーアンテナが、OFDM信号のプリンアンプル信号を時間軸上の信号として採用した例について説明したが、これに限らず、OFDM信号のプリンアンプル信号をFFT処理(周波数分別)した各弁別信号を採用するようにしてもよい。この場合の構成を、図5～図8に示す。図5は、本第3実施形態のアダプティブアレーアンテナの構成を示す図で、図6は、図5中のFFT回路83の詳細構成を示す図ある。図7は、図5の遅延回路90の作動を示す図で、図8は、図6中のFFT回路の作動を示す図である。

【0081】本第3実施形態では、図5に示すように、MMSE演算回路40Bが、図1中のMMSE演算回路40Aに代えて採用されて、乗算器201～20Mが、図1中の乗算器21～2Mに代えて採用されている。乗算器510～530が、図1中の乗算器51～53に代えて採用されている。さらに、FFT回路801～80M、83、84が追加されている。FFT回路801は、アンテナ素子11の受信OFDM信号 $x_1(i)$ のプリンアンプル信号をFFT処理する。具体的には、FFT回路801は、上記プリンアンプル信号の有効シンボル(図17参照)毎にN(Nは自然数)回だけサンプリング(アナログデジタル変換)して各サンプリング信号に基づいてFFT処理して周波数毎の弁別信号 $ft_1(1)$ 、 $ft_1(2) \dots ft_1(N)$ を出力し得る。ここで、弁別信号 $ft_1(1)$ 、 $ft_1(2) \dots ft_1(N)$ を、まとめて、数式14で表すことができる。また、Nは、上記有効シンボルのサンプリング回数であって、上記有効シンボルのFFTのポイント数である。

【0082】

$$[\text{数}14] FT_1(i) = [ft_1(1) \quad ft_1(2) \quad ft_1(3) \dots ft_1(N)]^T$$

FFT回路802は、FFT回路801と実質的に同様に、アンテナ素子11の受信OFDM信号 $x_1(i)$ のプリンアンプル信号をFFT処理して、周波数毎の弁別信号 $ft_2(1)$ 、 $ft_2(2) \dots ft_2(N)$ を出力する。さらに、弁別信号 $ft_2(1)$ 、 $ft_2(2) \dots ft_2(N)$ を、まとめて、数式15で表せる。

【0083】

$$[\text{数}15] FT_2(i) = [ft_2(1) \quad ft_2(2) \quad ft_2(3) \dots ft_2(N)]^T$$

FFT回路80Mは、FFT回路801と実質的に同様に、アンテナ素子1Mの受信OFDM信号 $x_M(i)$ のプリンアンプル信号をFFT処理して、周波数毎の弁別信号 $ft_M(1)$ 、 $ft_M(2) \dots ft_M(N)$ を出力する。さらに、弁別信号 $ft_M(1)$ 、 $ft_M(2) \dots ft_M(N)$ を、まとめて、数式16で表せる。

【0084】

$$[\text{数}16] FT_M(i) = [ft_M(1) \quad ft_M(2) \quad ft_M(3) \dots ft_M(N)]^T$$

$$ft_M(3) \dots ft_M(N)]^T$$

ここで、本第3実施形態では、 $FT_1(i)$ 、 $FT_2(i)$ 、 $\dots FT_M(i)$ をまとめて、数式17に示すように、弁別信号 $X(i)'$ とする

【0085】

$$[\text{数}17] X(i)' = [FT_1(i) \quad FT_2(i) \dots FT_M(i)]^T$$

次に、乗算器201～20Mは、アンテナウエイト W'' に弁別信号 $X(i)'$ に乗算する。すなわち、乗算器201は、アンテナウエイト w_1'' と $FT_1(i)$ との積を求めて結果 $(w_1'' \cdot FT_1(i))$ を得る。乗算器202は、アンテナウエイト w_2'' と $FT_2(i)$ との積を求めて結果 $(w_2'' \cdot FT_2(i))$ を得る。さらに、乗算器20Mは、アンテナウエイト w_M'' と $FT_M(i)$ との積を求めて結果 $(w_M'' \cdot FT_M(i))$ を得る。

【0086】次に、加算器(Σ)300は、乗算器201～20Mによる結果 $(w_1'' \cdot FT_1(i))$ 、 $(w_2'' \cdot FT_2(i))$ 、 $\dots (w_M'' \cdot FT_M(i))$ を周波数毎に加算することにより、アンテナウエイト W と弁別信号 $X(i)'$ との内積を示す内積信号 $W''X(i)'$ を求める。

【0087】因みに、内積信号 $W''X(i)'$ としては、数式18に示すように、 $fx_1(1)$ 、 $fx_2(2)$ 、 $\dots fx_M(N)$ といったN個の内積信号をまとめたものである。さらに、例えば、内積信号は $fx_1(1)$ は、数式19で表すことができ、内積信号 $fx_2(2)$ は、数式20で表すことができる。さらに、内積信号 $fx_M(N)$ は、数式21で表すことができる。

【0088】

$$[\text{数}18] W''X(i)' = [fx_1(1) \quad fx_2(2) \dots fx_M(N)]^T$$

【0089】

$$[\text{数}19] fx_1(1) = w_1'' \cdot ft_1(1) + w_2'' \cdot ft_2(1) \dots w_M'' \cdot ft_M(1)$$

【0090】

$$[\text{数}20] fx_2(2) = w_1'' \cdot ft_1(2) + w_2'' \cdot ft_2(2) \dots w_M'' \cdot ft_M(2)$$

【0091】

$$[\text{数}21] fx_M(N) = w_1'' \cdot ft_1(N) + w_2'' \cdot ft_2(N) \dots w_M'' \cdot ft_M(N)$$

次に、遅延回路90は、図6に示すように、発生器60からのOFDM信号のプリンアンプル信号 $r_s(i)$ (所望既知信号)を受けて、このプリンアンプル信号 $r_s(i)$ に対する遅延プリンアンプル信号 $OF(t+t_s)$ 、 $OF(t+2 \cdot t_s)$ 、 $OF(t+3 \cdot t_s) \dots OF(t+p \cdot t_s)$ を発生する。

【0092】但し、 t_s は、FFT回路801～80Mのサンプリング周期を示す時間で、 $(p+1)$ は、OFDMシンボルのガードインターバルGIを時間 t_s でサンプリングした場合のサンプリングの回数である。

【0093】これにより、遅延プリアンブル信号OF(t+t_s)、OF(t+2・t_s)…OF(t+p・t_s)は、それぞれ、プリアンブル信号r_s(i)に対してガードインターバル期間T_gより短い遅延時間を有する。さらに、遅延プリアンブル信号の個数としては、ガードインターバル期間T_gとサンプリング周期t_sとで定める最大個数である{p=(T_g/t_s)-1}。

【0094】ここで、遅延プリアンブル信号OF(t+t_s)は、図7に示すように、プリアンブル信号r_s(i)に対して時間t_sだけ遅延させた信号で、遅延プリアンブル信号OF(t+2・t_s)は、プリアンブル信号r_s(i)に対して時間2・t_sだけ遅延させた信号で、遅延プリアンブル信号OF(t+3・t_s)は、プリアンブル信号r_s(i)に対して時間3・t_sだけ遅延させた信号である。遅延プリアンブル信号OF(t+p・t_s)は、プリアンブル信号r_s(i)に対して時間p・t_sだけ遅延させた信号である。

【0095】次に、FFT回路83は、図6に示すように、遅延回路90からの遅延プリアンブル信号OF(t+t_s)、OF(t+2・t_s)、OF(t+3・t_s)…OF(t+p・t_s)のそれぞれの有効シンボルを並列的にサンプリング周期t_sでサンプリングしてそのサンプリング信号でFFT処理する。具体的には、FFT回路83は、FFT処理部831、832、833…83pを有し、FFT処理部831は、図8に示すように、遅延プリアンブル信号OF(t+t_s)の有効シンボルをサンプリング周期t_sでFFT処理して遅延弁別信号R(1)を出力する。但し、遅延弁別信号R(1)は、数式22で表せる。この遅延弁別信号R(1)は、周波数毎の信号成分を有する。

【0096】

$$[数22] R(1) = [f_1(1) \quad f_1(2) \quad f_1(3) \cdots f_1(N)]^T$$

また、FFT処理部832は、図8に示すように、遅延プリアンブル信号OF(t+2・t_s)の有効シンボルをサンプリング周期t_sでFFT処理することにより、数式23に示す遅延弁別信号R(2)を出力する。この遅延弁別信号R(2)は、周波数毎の信号成分を有する。さらに、FFT処理部83pは、図8に示すように、遅延プリアンブル信号OF(t+p・t_s)の有効シンボルをサンプリング周期t_sでFFT処理することにより、数式24に示す遅延弁別信号R(p)を出力する。遅延弁別信号R(p)は、周波数毎の信号成分を有する。

【0097】

$$[数23] R(2) = [f_2(1) \quad f_2(2) \quad f_2(3) \cdots f_2(N)]^T$$

【0098】

$$[数24] R(p) = [f_p(1) \quad f_p(2) \quad f_p(3) \cdots f_p(N)]^T$$

次に、図5に示すFFT回路84は、図8に示すように、発生器60からのOFDM信号のプリアンブル信号r_s(i)(=OF(t))の有効シンボルをサンプリング周期t_sでサンプリングしてこれらサンプリング信号でFFT処理する。これにより、FFT回路84は、数式25に示すように、所望弁別信号r_s(i)'を出力する。所望弁別信号r_s(i)'は、周波数毎の信号成分を有する。

【0099】

$$[数25] r_s(i)' = [f_s(1) \quad f_s(2) \quad f_s(3) \cdots f_s(N)]^T$$

次に、乗算器530は、信号ウエイトA"と遅延弁別信号R(i)との積をとって出力信号{A"R(i)}を出力する。但し、本第3実施形態での信号ウエイトAは、数式26に示すようになっている。なお、出力信号{A"R(i)}は、N個の出力信号をまとめて表記されたものである。

【0100】

$$[数26] A = [a_1 \quad a_2 \quad \cdots a_p]^T$$

さらに、加算器520は、乗算器530の出力信号{A"R(i)}と所望弁別信号r_s(i)'とを加算して加算信号(r_s(i)' + A"R(i))を出力する。加算器510は、加算信号(r_s(i)' + A"R(i))と加算器30の内積信号W"X(i)'との誤差e(i)を求める。

【0101】ここで、MMSE演算器40Bには、弁別信号X(i)'、遅延弁別信号R(i)、及び、誤差e(i)が入力されて、MMSE演算器40Bは、上記第1、第2実施形態と同様に、MMSE方式のSMI法に基づいて誤差e(i)を小さくするようにアンテナウエイトWを更新するとともに、信号ウエイトAを更新する。これにより、加算器300の内積信号W"X(i)'としては、弁別信号X(i)'のうち所望弁別信号r_s(i)'(所望既知信号)と遅延弁別信号R(i)(他の既知信号)とを除く成分が抑圧された信号になる。これにより、上記第1、第2実施形態と実質的に同様の効果が得られる。

【0102】なお、上記第3実施形態では、遅延プリアンブル信号OF(t+t_s)、OF(t+2・t_s)、OF(t+3・t_s)…OF(t+p・t_s)に基づいて遅延弁別信号R(i)を得るようにした例について説明したが、これに限らず、所望弁別信号r_s(i)'に基づいて遅延弁別信号R(i)を得てもよい。

【0103】(第4実施形態)上記第1～3実施形態では、MMSE方式のアダプティブアレーアンテナが、OFDM信号を受信する例について説明したが、これに限らず、MMSE方式のアダプティブアレーアンテナをCDMA通信に適用してもよい。この場合の構成を図9に示す。

【0104】図9では、図3に示す回路にマッチドフィ

ルタ100及びRAKE合成器110が追加されて構成されている。さらに、図3に示す遅延回路80に代えて、遅延回路80Aが採用されている。図9において、図1中の符号と同一符号は、同一物、或いは、実質的同一物を示す。但し、各アンテナ素子11…1MがOFDM信号に代えてCDMA信号を受信して、受信CDMA信号 $x_1(i)$ 、 $x_2(i)$ 、… $x_M(i)$ を出力する。

【0105】次に、本第4実施形態の作動について図10を参照して説明する。以下、4個のアンテナ素子11～14を採用して、アンテナ素子11～14がそれぞれ、を出力する例について説明する。マッチドフィルタ100は、受信CDMA信号 $x_1(i)$ 、 $x_2(i)$ 、 $x_3(i)$ 、 $x_4(i)$ をそれぞれと発生器60からのパイロット信号（既知信号） $r_0(i)$ との相関検出を並列的に行う。

【0106】具体的には、マッチドフィルタ100は、第1～第4のマッチドフィルタ部（図示せず）を有している。第1のマッチドフィルタ部は、受信CDMA信号 $x_1(i)$ とパイロット信号 $r_0(i)$ との相関検出をして相関信号（図10（a）参照）を出力し、第2のマッチドフィルタ部は、受信CDMA信号 $x_2(i)$ とパイロット信号 $r_0(i)$ との相関検出をして相関信号（図10（b）参照）を出力する。

【0107】第3のマッチドフィルタ部は、受信CDMA信号 $x_3(i)$ とパイロット信号 $r_0(i)$ との相関検出をして相関信号（図10（c）参照）を出力し、第4のマッチドフィルタ部は、受信CDMA信号 $x_4(i)$ とパイロット信号 $r_0(i)$ との相関検出をして相関信号（図10（d）参照）を出力する。但し、図10（a）～（d）では、縦軸は、相関値を示し、横軸は時間を示す。

【0108】ここで、マッチドフィルタ100は、第1～第4のマッチドフィルタ部からの相関信号を加算してその加算結果に基づいて、パイロット信号 $r_0(i)$ （所望信号）の入力時を基準とした遅延情報を得る。この遅延情報は、受信CDMA信号 $x_1(i) \sim x_4(i)$ のうち所望の時間より短い遅延時間の遅延信号を示すものである。図10（e）に示す例では、遅延情報としては、 t_{d1} 、 t_{d2} 、 t_{d3} 、… t_{d6} が得られるた例を示す。そこで、遅延回路80Aは、遅延情報 $t_{d1} \sim t_{d6}$ を用いて、図10（f）に示すように、遅延信号 $R(i)$ （他の既知信号）を出力する。

【0109】すなわち、遅延回路80Aは、 $r_0(t+t_{d1})$ 、 $r_0(t+t_{d2})$ 、 $r_0(t+t_{d2}) \dots r_0(t+t_{d6})$ を出力する。例えば、 $r_0(t+t_{d1})$ は、パイロット信号 $r_0(i)$ に対して遅延時間 t_{d1} だけ遅延しており、 $r_0(t+t_{d2})$ は、パイロット信号 $r_0(i)$ に対して遅延時間 t_{d2} だけ遅延している。 $r_0(t+t_{d6})$ は、パイロット信号 r

。 (i) に対して遅延時間 t_{d6} だけ遅延している。その他の作動は、図3に示す回路と実質的に同様である。

【0110】以上により、加算器（ Σ ）からの内積信号 $W^H X$ としては、受信CDMA信号 $x_1(i) \dots x_M(i)$ のうちパイロット信号 $r_0(i)$ （所望信号）及びその遅延信号 $r_0(t+t_{d1}) \sim r_0(t+t_{d6})$ （他の既知信号）を除く成分が抑圧された信号が得られる。そして、RAKE合成器110は、当該内積信号 $W^H X$ を用いて、RAKE合成復調を行うことになる。ここで、遅延信号 $r_0(t+t_{d1}) \sim r_0(t+t_{d6})$ として、RAKE合成復調に必要な信号を用意すれば、RAKE合成復調に不必要な信号の抑圧のためにヌル点を形成できる。従って、上記第1実施形態と同様に、MMSE方式のアダプティブアレーアンテナの自由度の無駄な消費を抑え得る。

【0111】なお、上記第4実施形態においては、CDMA方式の通信にMMSE方式のアダプティブアレーアンテナを適用して、マッチドフィルタ100でCDMA受信信号 $X(i)$ の遅延情報を得る例を示したが、これに限らず、上記第1、第2実施形態の受信OFDM信号の遅延情報をマッチドフィルタ100で得るようにしてもよい。

【0112】（第5実施形態）上記2実施形態では、所望既知信号及び他の既知信号及びを予め設定した例について説明したが、これに限らず、受信OFDM信号 $X(i)$ に応じて、遅延信号 $R(i)$ のうち所望既知信号及び他の既知信号を選択するようにしてもよい。

【0113】この場合の構成を図11、図12に示す。図11は、本第5実施形態でのMMSE方式のアダプティブアレーアンテナの構成を示す。図12は、図11中の所望信号選択回路（以下、所望信号選択回路130）の詳細構成を示す。

【0114】本第5実施形態のMMSE方式のアダプティブアレーアンテナは、図11に示すように、図3に示す回路に所望信号選択回路130が追加されている。図11において、図3の示す同一符号は、同一物、或いは、実質的に同一物を示す。

【0115】遅延回路90は、発生器60からのブリアンブル信号 $r_0(i)$ を受けて、遅延ブリアンブル信号 $OF(t+t_s)$ 、 $OF(t+2 \cdot t_s) \dots OF(t+U \cdot t_s)$ を発生する。但し、 U は自然数であって、ブリアンブル信号 $r_0(i)$ に対する遅延ブリアンブル信号 $OF(t+t_s) \dots OF(t+U \cdot t_s)$ のそれぞれの遅延時間は、OFDM信号のガードインターバル期間 T に比べて短い。

【0116】所望信号選択回路130には、受信OFDM信号 $X(i)$ 及び遅延ブリアンブル信号 $OF(t+t_s) \dots OF(t+U \cdot t_s)$ が入力されて、所望信号選択回路130は、受信OFDM信号 $X(i)$ に応じて、遅延ブリアンブル信号 $OF(t+t_s) \dots OF(t+U \cdot$

t_s)のうち所望既知信号 $r_i(i)$ 及び遅延信号 $R(i)$ を選択する。

【0117】具体的には、所望信号選択回路130は、図12に示すように、相関器131a~131c、132a~132c、133a~133c、134a~134c、加算器(Σ)135a~135c、最大値判定器136、及び、選択回路137から構成されている。

【0118】次に、本第5実施形態の作動について図12を参照して説明する。以下、アンテナ素子11~14といった4つのアンテナ素子だけを採用し、遅延プリアンブル信号OF($t+t_s$)、OF($t+2 \cdot t_s$)、OF($t+3 \cdot t_s$)といった3個の遅延プリアンブル信号を採用した例について説明する。まず、アンテナ素子11~14は、受信OFDM信号 $x_1(i)$ 、 $x_2(i)$ 、 $x_3(i)$ 、 $x_4(i)$ を、それぞれ、出力する。

【0119】次に、相関器131aは、遅延プリアンブル信号OF($t+t_s$)と受信OFDM信号 $x_1(i)$ との相関検出を行い、相関器132aは、遅延プリアンブル信号OF($t+t_s$)と受信OFDM信号 $x_2(i)$ との相関検出を行う。相関器133aは、遅延プリアンブル信号OF($t+t_s$)と受信OFDM信号 $x_3(i)$ との相関検出を行い、相関器134aは、遅延プリアンブル信号OF($t+t_s$)と受信OFDM信号 $x_4(i)$ との相関検出を行う。

【0120】加算器135aは、相関器131a、132a、133a、134aのそれぞれからの相関検出信号を加算して加算信号を出力する。ここで、加算器135aの加算信号は、遅延プリアンブル信号OF($t+t_s$)と、受信OFDM信号 $x_1(i)$ 、 $x_2(i)$ 、 $x_3(i)$ 、 $x_4(i)$ との相関を示す。

【0121】次に、相関器131bは、遅延プリアンブル信号OF($t+2 \cdot t_s$)と受信OFDM信号 $x_1(i)$ との相関検出を行い、相関器132bは、遅延プリアンブル信号OF($t+2 \cdot t_s$)と受信OFDM信号 $x_2(i)$ との相関検出を行う。相関器133bは、遅延プリアンブル信号OF($t+2 \cdot t_s$)と受信OFDM信号 $x_3(i)$ との相関検出を行い、相関器134bは、遅延プリアンブル信号OF($t+2 \cdot t_s$)と受信OFDM信号 $x_4(i)$ との相関検出を行う。

【0122】加算器135bは、相関器131b、132b、133b、134bのそれぞれからの相関検出信号を加算して加算信号を出力する。加算器135bの加算信号は、遅延プリアンブル信号OF($t+2 \cdot t_s$)と、受信OFDM信号 $x_1(i)$ 、 $x_2(i)$ 、 $x_3(i)$ 、 $x_4(i)$ との相関を示す。

【0123】次に、相関器131cは、遅延プリアンブル信号OF($t+3 \cdot t_s$)と受信OFDM信号 $x_1(i)$ との相関検出を行い、相関器132cは、遅延プリアンブル信号OF($t+3 \cdot t_s$)と受信OFDM

信号 $x_2(i)$ との相関検出を行う。相関器133cは、遅延プリアンブル信号OF($t+3 \cdot t_s$)と受信OFDM信号 $x_3(i)$ との相関検出を行い、相関器134cは、遅延プリアンブル信号OF($t+3 \cdot t_s$)と受信OFDM信号 $x_4(i)$ との相関検出を行う。

【0124】加算器135cは、相関器131c、132c、133c、134cのそれぞれからの相関検出信号を加算して加算信号を出力する。加算器135cの加算信号は、遅延プリアンブル信号OF($t+3 \cdot t_s$)と、受信OFDM信号 $x_1(i)$ 、 $x_2(i)$ 、 $x_3(i)$ 、 $x_4(i)$ との相関を示す。

【0125】次に、最大値判定器136は、加算器135a~135cからのそれぞれの加算信号のうち最大値となる加算信号(以下、最大値加算信号という)を判定し、この最大値加算信号を示す最大値識別信号を選択回路137に出力する。選択回路137は、遅延プリアンブル信号OF($t+t_s$)、OF($t+2 \cdot t_s$)、OF($t+3 \cdot t_s$)のうち、最大値識別信号に対応する遅延プリアンブル信号を所望既知信号 $r_i(i)$ として選択して出力する。さらに、選択回路137は、遅延プリアンブル信号OF($t+t_s$)、OF($t+2 \cdot t_s$)、OF($t+3 \cdot t_s$)のうち、最大値識別信号に対応する遅延プリアンブル信号を除く、2つの遅延プリアンブル信号を他の既知信号 $R(i)$ として出力する。その他の作動は、上記第2実施形態と実質的に同様である。

【0126】なお、上記第5実施形態においては、4つのアンテナ素子11~14を採用した例について説明したが、これに限らず、アンテナ素子の個数は、2個以上であるならば、幾つでもよい。さらに、上記第5実施形態では、3個の遅延プリアンブル信号OF($t+t_s$)、OF($t+2 \cdot t_s$)、OF($t+3 \cdot t_s$)を採用した例につき説明したが、これに限らず、遅延プリアンブル信号の個数は、幾つでもよい。

【0127】なお、本発明の実施にあたり、本第5実施形態に示す相関器としては、スライディング相関器、マッチドフィルタ等の各種相関器を適用してもよい。

【0128】(第6実施形態)本第6実施形態では、上記第2実施形態の回路に等化回路(以下、等化回路120という)が追加された回路が採用され、等化回路120によって、加算器30の内積信号 $W^H X(i)$ のうちの他の既知信号を抑圧しその抑圧された信号を出力信号として出力する。この場合の構成を図13、図14に示す。

【0129】図13は、本第6実施形態のMMSE方式のアダプティブアレーアンテナの構成を示す図である。図14は、図13中の等化回路120の詳細構成を示す。図13において、図3中の同一符号は、同一物、或いは、実質的に同一物を示す。

【0130】本第6実施形態では、MMSE方式のアダプティブアレーアンテナが、OFDM通信方式ではな

く、QPSK通信方式に適用されている。このため、アンテナ素子11~1Mは、QPSK信号(パイロット信号)を受信する。

【0131】従って、アンテナ素子11~1Mは、それぞれ、受信OFDM信号 $X(i)$ に代えて、受信QPSK信号 $X(i)$ を出力する。また、発生回路60は、QPSK信号のパイロット信号 $r_0(i)$ を所望既知信号として出力し、遅延回路90は、QPSK信号のパイロット信号 $r_0(i)$ に対して所望期間だけ遅延した遅延パイロット信号 $R(i)$ を他の既知信号として出力する。MMSE演算器40Aは、上記第2実施形態と実質的に同様に、アンテナウエイト W^* と信号ウエイト A^* とを更新する。また、加算器(Σ)30は、受信QPSK信号 $X(i)$ のうち所望パイロット信号(所望既知信号)とその遅延パイロット信号(他の既知信号)との双方を除く成分が抑圧された信号を、内積信号 W^*X として出力する。また、等化回路120は、図14に示すように、遅延器(Z^{-1})121~124、乗算器125~128、及び、加算器129、130から構成されている。次に、本第6実施形態の等化回路120の作動について図14、図15を参照して説明する。

【0132】以下、図15(a)に示すように、加算器(Σ)30の内積信号 W^*X として、所望パイロット信号QP1と遅延パイロット信号QP2~QP5との総和が採用された例について説明する。

【0133】ここで、遅延パイロット信号QP2~QP5といった4つの遅延パイロット信号が採用されているため、本第6実施形態でのMMSE演算器40Aの信号ウエイト(以下、信号ウエイト $A(G)$ という)を、数式27で表すことができる。 G は、サンプリングタイミング(更新タイミング)である($G=t_1, t_2, t_3, \dots$)。また、図15(b)は、タイミング $t_1 \sim t_5$ での遅延器121~124の出力を示す。

【0134】

【数27】 $A(G) = [a_1(G) \ a_2(G) \ a_3(G) \ a_4(G)]^T$

先ず、タイミング t_1 にて、図15(a)に示すQPSKシンボル Z_A が、加算器130を通して遅延器121に入力される。すなわち、等化回路120は、タイミング t_1 にて、QPSKシンボル Z_A を出力できる。

【0135】次に、タイミング t_2 にて、図15(b)に示すように、遅延器121は、QPSKシンボル Z_A を乗算器127に出力するとともに、QPSKシンボル Z_A を遅延器122に出力する。すると、乗算器128は、信号ウエイト $a_1(t_2)^*$ をQPSKシンボル Z_A に乗算して乗算信号($a_1(t_2)^*Z_A$)を加算器129に出力する。

【0136】ここで、信号ウエイト $a_1(t_2)^*$ (信号ウエイト A^*)は、上記第1実施形態で述べたように、MMSE演算器40Aによって、QPSKシンボル Z_A

{プリアンブル信号 $r_0(i)$ }を基準としたQPSKシンボル Z_A1 {遅延信号 $R(i)$ }の位相差及び振幅差を示すように求められる。このため、乗算信号($a_1(t_2)^*Z_A$)は、QPSKシンボル Z_A1 に等しくなる($Z_A1 = a_1(t_2)^*Z_A$)。

【0137】これにより、乗算器128は、乗算信号 Z_A1 を加算器129を通して加算器130に出力できる。また、加算器130には、加算器(Σ)30の内積信号 W^*X として、QPSKシンボル Z_B 、 Z_A1 が入力される。加算器130は、QPSKシンボル Z_B 、 Z_A1 と乗算信号 Z_A1 との差を求めて差分信号($=Z_B$)を遅延器121に出力する。すなわち、等化回路120は、タイミング t_2 にて、QPSKシンボル Z_B を出力できる。

【0138】次に、タイミング t_3 にて、遅延器122は、図15(b)に示すように、QPSKシンボル Z_A を乗算器127に出力するとともに、QPSKシンボル Z_A を遅延器123に出力する。すると、乗算器127は、信号ウエイト $a_2(t_3)^*$ をQPSKシンボル Z_A に乗算して乗算信号($a_2(t_3)^*Z_A$)を加算器129に出力する。

【0139】ここで、信号ウエイト $a_2(t_3)^*Z_A$ (信号ウエイト A^*)は、上記第1実施形態で述べたように、MMSE演算器40Aによって、QPSKシンボル Z_A {プリアンブル信号 $r_0(i)$ }を基準としたQPSKシンボル Z_A2 {遅延信号 $R(i)$ }の位相差及び振幅差を示すように求められる。このため、乗算信号($a_2(t_3)^*Z_A$)は、QPSKシンボル Z_A2 に等しくなる($Z_A2 = a_2(t_3)^*Z_A$)。従って、乗算器127は、QPSKシンボル Z_A2 を加算器129に出力する。

【0140】また、遅延器121は、図15(b)に示すように、QPSKシンボル Z_B を乗算器128に出力するとともに、QPSKシンボル Z_B を遅延器122に出力する。乗算器128は、信号ウエイト $a_1(t_3)^*$ をQPSKシンボル Z_B に乗算して乗算信号($a_1(t_3)^*Z_B$)を加算器129に出力する。

【0141】ここで、信号ウエイト $a_1(t_3)^*$ (信号ウエイト A^*)は、上記第1実施形態で述べたように、MMSE演算器40Aによって、QPSKシンボル Z_B {プリアンブル信号 $r_0(i)$ }を基準としたQPSKシンボル Z_B1 {遅延信号 $R(i)$ }の位相差及び振幅差を示すように求められる。

【0142】従って、乗算信号($a_1(t_3)^*Z_B$)は、QPSKシンボル Z_B1 に等しくなる($Z_B1 = a_1(t_3)^*Z_B$)。従って、乗算器127は、乗算信号 Z_B1 を加算器129に出力できる。

【0143】ここで、加算器129は、乗算器127の乗算信号 Z_B1 と加算器129のQPSKシンボル Z_A2 とを加算して加算信号($Z_B1 + Z_A2$)を加算器1

30に出力する。加算器130には、加算器(Σ)30の内積信号 W^*X として、QPSKシンボル ZC 、 $ZB1$ 、 $ZA2$ が入力されて、加算器130は、QPSKシンボル ZC 、 $ZB1$ 、 $ZA2$ と加算信号($ZB1+ZA2$)との差分を求め、差分信号 ZC を遅延器121に出力する。

【0144】すなわち、等化回路120は、タイミング $t3$ にて、QPSKシンボル ZC を出力できる。以下、等化回路120は、上述の作動と実質的に同様に作動して、タイミング $t4$ にて、QPSKシンボル ZD を出力し、タイミング $t5$ にて、QPSKシンボル ZE を出力する。

【0145】以上により、等化回路120は、上述の如く、QPSKシンボル $ZA\sim ZD$ だけを出力することができる。換言すれば、等化回路120は、加算器(Σ)30の内積信号 W^*X として、所望パイロット信号 $QP1$ と遅延パイロット信号 $QP2\sim QP5$ との総和を入力されて、遅延パイロット信号 $QP2\sim QP5$ を抑圧して所望パイロット信号 $QP1$ だけを出力することになる。

【0146】なお、上記第6実施形態では、MMSE方式のアダプティブアレーアンテナをQPSK通信方式に適用した例について説明したが、これに限らず、OFDM通信方式に適用してもよい。

【0147】さらに、本発明の実施にあたり、OFDM通信方式、CDMA通信方式、QPSK変調を用いた通信方式等以外に、各種通信方式を採用してもよい。

【0148】なお、第1～第6実施形態では、MMSE演算器40A、40BでMMSE方式のSMIアルゴリズムを採用した例について説明したが、MMSE方式であれば、その他のアルゴリズムを採用してもよい。

【0149】(第7実施形態)ところで、上記第1実施形態にて述べたMMSE方式のアダプティブアレーアンテナにおいては、所望信号と同一方向から干渉波が到来すると、その干渉波を抑圧できないという問題がある。すなわち、上記第1実施形態にて述べたMMSE方式のアダプティブアレーアンテナでは、加算器30の内積信号 W^*X は、受信OFDM信号 $X(i)$ のうちブリアンブル信号 $r_{\cdot}(i)$ とその遅延信号 $R(i)$ とを除く成分が抑圧された信号になるものの、ブリアンブル信号 $r_{\cdot}(i)$ と同一方向からGI外遅延信号(干渉波)が到来すると、そのGI遅延信号を抑圧できないことになる。

【0150】従来のPI方式のアダプティブアレーアンテナでは、到来波成分を、それに含まれる所望信号と干渉波とを区別することなく抑圧することは公知である。そこで、本第7実施形態において、従来のPI方式のアダプティブアレーアンテナに着目して成されたもので、所望波及びGI内遅延信号の双方の抑圧を防止し、かつ、所望信号と同一方向から到来する干渉波を抑圧して通信性能を向上させるようにする例につき説明する。こ

の場合の構成を図16に示す。

【0151】PI方式のアダプティブアレーアンテナは、アンテナ素子11～14、乗算器21…2M、加算器(Σ)30、PI演算器41、加算器51A、乗算器53A及び、遅延回路80Aから構成されている。図16において、図1中の符号と同一符号は、同一物、或いは、実質的同一物を示す。

【0152】遅延回路80Aは、上記第1実施形態で述べたブリアンブル信号 $r_{\cdot}(i)$ を受けて、このブリアンブル信号 $r_{\cdot}(i)$ と遅延信号 $R(i)$ とを出力する。以下、遅延回路80Aの出力信号を出力信号 $R(i)'$ という。

【0153】但し、ブリアンブル信号に対する遅延信号 $R(i)$ の遅延時間は、上述の如く、OFDMシンボルのガードインターバルGIの期間TGに比べて短く、遅延信号 $R(i)$ の数(サンプルポイント数)を16とする。

【0154】乗算器53Aは、信号ウエイトAを出力信号 $R(i)'$ に乗算して乗算信号 $\{A^*R(i)'\}$ を求める。加算器51Aは、乗算信号 $\{A^*R(i)'\}$ と加算器30の内積信号 $W^*X(i)$ とを加算して加算参照信号($W^*X(i)+A^*R(i)'$)を求める。

【0155】PI演算器41には、加算参照信号($W^*X(i)+A^*R(i)'$)、出力信号 $R(i)'$ 、及び、受信OFDM信号 $X(i)$ が入力されて、PI演算器41は、加算参照信号の電力 $|W^*X(i)+A^*R(i)'|^2$ を最小にするようにアンテナウエイトW及び信号ウエイトAを更新する。このとき、信号ウエイトAは、内積信号 $W^*X(i)$ に含まれる信号成分のうち、出力信号 $R(i)'$ を打ち消すウエイトになり、アンテナウエイトWは、受信OFDM信号 $X(i)$ に含まれる干渉波成分の電力を最小にするウエイトになる。

【0156】換言すれば、PI演算器41は、加算参照信号の電力($W^*X(i)+A^*R(i)'$)のうち、出力信号 $R(i)'$ を除く成分の電力を最小にするようにアンテナウエイトW及び信号ウエイトAを更新する。

【0157】図17において、所望信号とGI外遅延信号とが同一方向から到来したときのシュミレーションの結果を示す。図17において、第1～第5波が到来したとき、PI方式のアダプティブアレーアンテナ、MMSE方式のアダプティブアレーアンテナの動作後の指向性を示す。右縦軸は、MMSE方式のアダプティブアレーアンテナを基準とした受信電波の受信角度[deg]、左縦軸は、PI方式のアダプティブアレーアンテナを基準とした受信電波の受信角度[deg]である。横軸は抑圧比(dB)である。

【0158】図17において、MMSE方式のアダプティブアレーアンテナと、PI方式のアダプティブアレーアンテナとでは、アンテナゲインが異なるため、GI内

遅延信号がの方向のゲインが同じになるように表している。

【0159】ここで、鎖線は、MMSE方式のアダプティブアレーアンテナを用いたシュミレーションの結果を示す。実線は、PI方式のアダプティブアレーアンテナを用いたシュミレーションの結果を示す。図17から分かるように、MMSE方式のアダプティブアレーアンテナでは、所望信号と同一方向のGI外遅延信号が抑圧されていないが、PI方式のアダプティブアレーアンテナでは、所望信号と同一方向のGI外遅延信号が抑圧され

ている。
【0160】(第8実施形態) 本第8実施形態では、図18に示すように、上記第7実施形態の示す構成に、ローパスフィルタ420~425が追加されている。図18において、ローパスフィルタ420~424は、受信OFDM信号 $X(i)$ に基づいて狭帯域のOFDM信号

信号を求める。
【0161】ローパスフィルタ420~424は、受信OFDM信号 $X(i)$ のうちその所定周波数帯域の成分(図19参照)だけを取り出すことにより、狭帯域OFDM信号信号を出力する。つまり、狭帯域のOFDM信号信号は、受信OFDM信号 $X(i)$ の周波数帯域を狭くした信号になる。

【0162】ローパスフィルタ425は、プリアンブル信号 $r(i)$ に基づいて狭帯域プリアンブル信号を求める。つまり、ローパスフィルタ425は、プリアンブル信号 $r(i)$ のうちその所定周波数帯域の成分だけを取り出すことにより、狭帯域プリアンブル信号を出力する。

【0163】これに伴い、遅延回路80Aは、狭帯域プリアンブル信号に対して異なる遅延時間を有するU(図19では、8)個の遅延信号を求め、この遅延信号と狭帯域プリアンブル信号との双方を出力信号 $R(i)'$ として出力する。但し、プリアンブル信号に対する遅延信号の遅延時間は、上述の如く、OFDMシンボルのガードインターバルGIの期間TGに比べて短い。

【0164】ここで、出力信号 $R(i)'$ のうち遅延信号の採用数(サンプルポイント)は、受信OFDM信号 $X(i)$ の周波数帯域によって決まり、その周波数帯域を狭くすると、減らすことができる。

【0165】そこで、本第8実施形態のPI演算器41は、アンテナウエイトW及び信号ウエイトAの更新にあたり、OFDM信号信号に代えて狭帯域OFDM信号信号を採用し、プリアンブル信号に基づいた出力信号 $R(i)'$ に代えて、狭帯域プリアンブル信号に基づいた出力信号 $R(i)'$ を採用する。このため、 $R(i)$ の採用数を減らすことは勿論のこと、アンテナウエイトW及び信号ウエイトAを更新回数を減らすことが可能になり、ウエイト更新の計算量を減らし得る。

【0166】(第9実施形態) 上記第3実施形態では、

OFDM信号のプリアンブル信号を時間軸上の信号として採用したMMSE方式のアダプティブアレーアンテナについて説明したが、本第9実施形態では、これに限らず、OFDM信号のプリアンブル信号をFFT処理(周波数分別)した各弁別信号を採用したPI方式のアダプティブアレーアンテナにつき説明する。この場合の構成を、図20に示す。

【0167】PI方式のアダプティブアレーアンテナは、アンテナ素子11~14、乗算器201~204、加算器(Σ)300、FFT回路801~804、FFT回路834、PI演算器42、加算器510A、乗算器530A、及び、遅延回路80Aから構成されている。図20において、図5中の符号と同一符号は、同一物を示す。

【0168】遅延回路80Aは、上記第8実施形態で述べた如く、プリアンブル信号 $r(i)$ と遅延信号 $R(i)$ とを併せて出力信号 $R(i)'$ として出力する。FFT回路834は、プリアンブル信号 $r(i)$ と遅延信号 $R(i)$ とのそれぞれの有効シンボルを並列的にサンプリング周期 t_s でサンプリングしてそのサンプリング信号でFFT処理して弁別信号 $RFT(i)$ を出力する。

【0169】乗算器530Aは、信号ウエイトAを弁別信号 $RFT(i)$ に乗算して乗算信号 $\{A^*RFT(i)\}$ を求める。加算器510Aは、乗算信号 $\{A^*RFT(i)\}$ と加算器300の内積信号 $W^*X(i)'$ とを加算して加算参照信号 $(W^*X(i)') + A^*RFT(i)$ を求める。

【0170】PI演算器42には、弁別信号 $X(i)'$ 、加算参照信号 $(W^*X(i)') + A^*RFT(i)'$ 、及び、弁別信号 $RFT(i)$ が入力されて、PI演算器42は、加算参照信号の電力 $|W^*X(i)'+A^*RFT(i)'|^2$ を最小にするようにアンテナウエイトW及び信号ウエイトAを更新する。このとき、信号ウエイトAは、内積信号 $W^*X(i)'$ に含まれる信号成分のうち、弁別信号 $RFT(i)$ を打ち消すウエイトになり、アンテナウエイトWは、弁別信号 $X(i)'$ に含まれる干渉波成分の電力を最小にするウエイトになる。

【0171】換言すれば、PI演算器42は、加算参照信号 $(W^*X(i)'+A^*RFT(i)')$ のうち、弁別信号 $RFT(i)$ を除く成分の電力を最小にするようにアンテナウエイトW及び信号ウエイトAを更新する。

(第10実施形態) 本第10実施形態における、SMI方式のアダプティブアレーアンテナは、図21に示すように、アンテナ素子11、12、発生器60、FFT回路83、801、802、乗算器201、202、加算器(Σ)300、位相回転器1000、相関器1010、選択回路1020、演算器1030から構成されている。

【0172】演算器1030は、相関行列推定器1031、逆行列演算器1032、相関ベクトル推定器1033、及び、行列乗算器1034を有する。なお、図21において、図1、図2中の同一符号は、同一物を示す。

【0173】まず、アンテナ素子11で受信された受信OFDM信号 $x_1(i)$ のプリアンブル信号は、FFT回路801でFFT処理されて、周波数毎に弁別信号 $ft_1(1)$ 、 $ft_1(2)$ 、 $ft_1(3)$ 、 $ft_1(4)$ が求められる。また、アンテナ素子12で受信された受信OFDM信号 $x_2(i)$ は、FFT回路802でFFT処理されて、周波数毎に弁別信号 $ft_2(1)$ 、 $ft_2(2)$ 、 $ft_2(3)$ 、 $ft_2(4)$ が求められる。なお、弁別信号の括弧内の数字1…4は、FFTのポイント数を示す。

【0174】ここで、受信OFDM信号 $x_1(i)$ 、 $x_2(i)$ 、弁別信号 $ft_1(1) \sim ft_1(3)$ 、及び弁別信号 $ft_2(1) \sim ft_2(3)$ を次のようにベクトル表記される。

【0175】

$$[数28] X(i) = [x_1(i) \quad x_2(i)]^T$$

【0176】

$$[数29] FT_1(i) = [ft_1(1) \quad ft_1(2) \quad ft_1(3)]^T$$

【0177】

$$[数30] FT_2(i) = [ft_2(1) \quad ft_2(2) \quad ft_2(3)]^T$$

乗算器201は、アンテナウエイト w_1^* と $FT_1(i)$ との行列積($w_1^* FT_1(i)$)を求め、乗算器202は、アンテナウエイト w_2^* と $FT_2(i)$ との行列積($w_2^* FT_2(i)$)を求める。

【0178】次に、加算器(Σ)300は、乗算器201、202による行列積($w_1^* FT_1(i)$)、($w_2^* FT_2(i)$)を、周波数毎に加算する。すなわち、行列積($w_1^* FT_1(i)$)、($w_2^* FT_2(i)$)、アンテナウエイト w_1^* 、 w_2^* を、数式31、32のようにベクトル表記すると、加算器(Σ)300によって、アンテナウエイト W と弁別信号 $X(i)^T$ との内積を示す内積信号 $W^H X(i)^T$ が求められる。また、内積信号 $W^H X(i)^T$ は、数式33に示すようにベクトル表記される。

【0179】

【数31】

$$X(i)^T = [FT_1(i) \quad FT_2(i)]^T$$

【0180】

$$[数32] W = [w_1 \quad w_2]^T$$

【0181】

$$[数33] W^H X(i)^T = [w_1^* ft_1(1) + w_2^* ft_2(1) \quad w_1^* ft_1(2) + w_2^* ft_2(2) \quad w_1^* ft_1(3) + w_2^* ft_2(3)]^T$$

次に、発生器60は、所望既知信号として、OFDM信

号のプリアンブル信号 $r_0(i)$ を発生し、このプリアンブル信号 $r_0(i)$ は、周波数軸上に複数のパイロットシンボル(既知信号)が配列された信号である。また、FFT回路83は、OFDM信号のプリアンブル信号 $r_0(i)$ をFFT処理して周波数毎に所望弁別信号 $rf_1(1)$ 、 $rf_1(2)$ 、 $rf_1(3)$ を求める。

【0182】次に、位相回転器1000は、所望弁別信号 $rf_1(1)$ を4種の位相量(0° 、 θ° 、 $2\theta^\circ$ 、 $3\theta^\circ$)だけ回転処理して、この回転処理された所望弁別信号 $rf_1(1 - \theta)$ 、 $rf_1(1 - 2\theta)$ 、 $rf_1(1 - 3\theta)$ と、所望弁別信号 $rf_1(1)$ とを出力する。

【0183】さらに、位相回転器1000は、所望弁別信号 $rf_1(2)$ を4種の位相量(0° 、 θ° 、 $2\theta^\circ$ 、 $3\theta^\circ$)だけ回転処理して、この回転処理された所望弁別信号 $rf_1(2 - \theta)$ 、 $rf_1(2 - 2\theta)$ 、 $rf_1(2 - 3\theta)$ と、所望弁別信号 $rf_1(2)$ とを出力する。

【0184】また、位相回転器1000は、所望弁別信号 $rf_1(3)$ を4種の位相量(0° 、 θ° 、 $2\theta^\circ$ 、 $3\theta^\circ$)だけ回転処理して、この回転処理された所望弁別信号 $rf_1(3 - \theta)$ 、 $rf_1(3 - 2\theta)$ 、 $rf_1(3 - 3\theta)$ と、所望弁別信号 $rf_1(3)$ とを出力する。

【0185】ここで、所望弁別信号 $rf_1(1) \sim rf_1(1 - 3\theta)$ 、 $rf_1(2) \sim rf_1(2 - 3\theta)$ 、 $rf_1(3) \sim rf_1(3 - 3\theta)$ は、数式34に示すように、求められる。

【0186】

【数34】

$$BS = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \\ C_{41} & C_{42} & C_{43} \end{bmatrix} \begin{bmatrix} rf_1(1) & 0 & 0 \\ 0 & rf_1(2) & 0 \\ 0 & 0 & rf_1(3) \end{bmatrix}$$

【0187】但し、 C_{tf} は、数式35に示す位相量、 t は位相量を示す番号、 f は周波数を示す番号である。また、数式35にて、 $C_{11} = C_{12} = C_{13}$ 、 $C_{21} = C_{22} = C_{23}$ 、 $C_{31} = C_{32} = C_{33}$ である。

【0188】

$$[数35] C_{tf} = \exp \{-2\pi j \cdot (j-1) \cdot (t-1)/3\}$$

ここで、位相回転器1000の出力信号は、図5に示すFFT回路84の出力信号とFFT回路83の出力信号とを併せたものと等価である。すなわち、FFT回路84は、位相回転器1000とともに、プリアンブル信号 $r_0(i)$ に対してガードインターバル期間 T_g より短い遅延時間を生成し、この生成された遅延時間をFFT処理することと同等の役割を果たす。

【0189】次に、相関器1010は、所望処理信号 B Sと弁別信号 $X(i)^T$ との相関値 K を求める。なお、

相関値Kは、所望処理信号BSと弁別信号X(i)'との行列積(BS×X(i)')により求められる。

【0190】選択回路1020は、相関値Kに基づいて、所望処理信号BSのうち、弁別信号X(i)'との相関が最も大きい所望処理信号BS_{max}を周波数毎に求める。

【0191】例えば、相関値Kを数式36のようにベクトル表記する。数式36中、相関値k_tfにおいてtは位相量を示す番号、fは周波数を示す番号である。

【0192】

【数36】

$$K = \begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \\ K_{31} & K_{32} \\ K_{41} & K_{42} \end{bmatrix}$$

【0193】まず、選択回路1020は、相関値k_tfの各々の絶対値を求め、各々の絶対値の二乗値(|k_tf|²)を求めるとともに、絶対値の二乗値(|k_tf|²)を、各々、位相量毎に、加算して、数式37に示す行列KGを求める。

【0194】

【数37】

$$KG = \begin{bmatrix} |K_{11}|^2 + |K_{12}|^2 \\ |K_{21}|^2 + |K_{22}|^2 \\ |K_{31}|^2 + |K_{32}|^2 \\ |K_{41}|^2 + |K_{42}|^2 \end{bmatrix}$$

【0195】次に、選択回路1020は、行列KGのうち最大値を求めるとともに、行列BSのうち、最大値の位相量に対応する所望弁別信号(以下、所望弁別信号_{mx}という)を周波数毎に求める。

【0196】ここで、所望弁別信号rf₁(1)…rf₁(2)…rf₁(3 3θ)を示す行列BSを数式38の如くベクトル表記する。

【0197】

【数38】

$$BS = \begin{bmatrix} rf_1(1) & rf_1(2) & rf_1(3) \\ rf_1(1 \theta) & rf_1(2 \theta) & rf_1(3 \theta) \\ rf_1(1 2\theta) & rf_1(2 2\theta) & rf_1(3 2\theta) \\ rf_1(1 3\theta) & rf_1(2 3\theta) & rf_1(3 3\theta) \end{bmatrix}$$

【0198】例えば、行列KGの最大値として、[|k₂₁|²+|k₂₂|²]が選択されたとき、数式38のうち周波数毎の所望弁別信号MX(i)として、[rf₁(1 2θ) rf₁(2 2θ)、rf₁(3 2

θ)]が選択される。さらに、数式38のうち周波数毎の所望弁別信号MX(i)以外の所望弁別信号を、数式39に示す如く、所望処理信号BAとする。但し、数式39の所望処理信号BAは、所望弁別信号MX(i)として、[rf₁(1 2θ) rf₁(2 2θ)、rf₁(3 2θ)]が選択された一例を示す。

【0199】

【数39】

$$BA = \begin{bmatrix} rf_1(1) & rf_1(2) & rf_1(3) \\ rf_1(1 \theta) & rf_1(2 \theta) & rf_1(3 \theta) \\ rf_1(1 3\theta) & rf_1(2 3\theta) & rf_1(3 3\theta) \end{bmatrix}$$

【0200】なお、以下、説明を簡易に行うため、所望処理信号BA(i)を、数式40に示すようにベクトル表記し、所望弁別信号MX(i)を数式41に示すようにベクトル表記する。数式40中、相関値b_at_fにおいてtは位相量を示す番号、fは周波数を示す番号である。数式41中、m_xtにおいて、tは位相量を示す番号である。

【0201】

【数40】

$$BA(i) = \begin{bmatrix} ba_{11}(i) & ba_{21}(i) & ba_{31}(i) \\ ba_{12}(i) & ba_{22}(i) & ba_{32}(i) \\ ba_{13}(i) & ba_{23}(i) & ba_{33}(i) \end{bmatrix}$$

【0202】

【数41】

$$MX(i) = \begin{bmatrix} mx_1 & mx_2 & mx_3 \end{bmatrix}$$

【0203】なお、以下、弁別信号X(i)'を、数式42に示す如くベクトル表記する。但し、数式42におけるf_{t_m}のMは自然数でアンテナ素子の番号を示し、fは周波数を示す。

【0204】

【数42】

$$X(i)' = \begin{bmatrix} ft_{11}(i) & ft_{12}(i) & ft_{13}(i) \\ ft_{21}(i) & ft_{22}(i) & ft_{23}(i) \end{bmatrix}$$

【0205】次に、相関行列推定器1031は、弁別信号X(i)'と所望処理信号BAとを併せて、数式43に示す行列XMを生成するとともに、数式44、数式45、数式46により、行列XMにおいて、個々の時刻での瞬時入力行列R_{x_{mx}m₁}、R_{x_{mx}m₂}、R_{x_{mx}m₃}を求める。数式47に基づいて瞬時入力行列R_{x_{mx}m₁}、R_{x_{mx}m₂}、R_{x_{mx}m₃}を平均化して、相関行列の推定値R_{x_{mx}m}を求める。

【0206】

【数43】

$$XM(i) = \begin{bmatrix} X'(i) \\ BA(i) \end{bmatrix} = \begin{bmatrix} ft_{11}(i) & ft_{12}(i) & ft_{13}(i) \\ ft_{21}(i) & ft_{22}(i) & ft_{23}(i) \\ ba_{11}(i) & ba_{21}(i) & ba_{31}(i) \\ ba_{12}(i) & ba_{22}(i) & ba_{32}(i) \\ ba_{13}(i) & ba_{23}(i) & ba_{33}(i) \end{bmatrix}$$

【0207】

【数44】 $R_{xxm1} = XM(1) \cdot XM(1)^*$

【0208】

【数45】 $R_{xxm2} = XM(2) \cdot XM(2)^*$

【0209】

【数46】 $R_{xxm3} = XM(3) \cdot XM(3)^*$

【0210】

【数47】

$R_{xxm} = (R_{xxm1} + R_{xxm2} + R_{xxm3}) / 3$

次に、逆行行列演算器1032は、相関行列の推定値 R_{xxm} の逆行行列 R_{xxm}^{-1} を求める。また、相関ベクトル推定器1033は、弁別信号 $X(i)^*$ 、所望弁別信号 MX 、及び、所望弁別信号 BA を用いて、数式48、数式49、数式50に示すように、個々の時刻における瞬時相関ベクトル r_{xnb1} 、 r_{xnb2} 、 r_{xnb3} を求める。

【0211】次に、相関ベクトル推定器1033は、数式51に基づいて、瞬時相関ベクトル r_{xnb1} 、 r_{xnb2} 、 r_{xnb3} を周波数上で平均化して相関ベクトル推定値 r_{xnb} を求める。

【0212】

【数48】 $r_{xnb1} = XM(1) \cdot MX(1)^*$

【0213】

【数49】 $r_{xnb2} = XM(2) \cdot MX(2)^*$

【0214】

【数50】 $r_{xnb3} = XM(3) \cdot MX(3)^*$

【0215】

【数51】 $r_{xnb} = (r_{xnb1} + r_{xnb2} + r_{xnb3}) / 3$

最後に、行列乗算器1034は、数式52に示すように、相関行列の推定値 R_{xxm} と相関ベクトル推定値 r_{xnb} とによって行列乗算して乗算結果 Z を求めるとともに、乗算結果 Z のうち「 w_1^* 」「 w_2^* 」を乗算器201、202にそれぞれ出力する。なお、数式51中、 $-a_1$ 、 $-a_2$ 、 $-a_3$ 、 $-a_4$ は、上記第3実施形態に述べた信号ウエイトである。

【0216】

【数式52】

$Z = [w_1^* \ w_2^* \ -a_1 \ -a_2 \ -a_3 \ -a_4]^T$

これにより、乗算器201、202は、行列積 ($w_1^* FT_1(i)$)、行列積 ($w_2^* FT_2(i)$) をそれぞれ求め、加算器(Σ)300によって、行列積 ($w_1^* FT_1(i)$)、($w_2^* FT_2(i)$) が、周波数毎に加算されて、内積信号 $W^* X(i)^*$ が求められる。

【0217】ここで、内積信号 $W^* X(i)^*$ のうち、所望処理信号 BA と所望弁別信号 MX とを除く成分を抑

圧するようにアンテナウエイト w_1 、 w_2 が更新される。これにより、抑圧の必要の無い所望処理信号 BA と所望弁別信号 MX との抑圧を防止して、上記第1、第2実施形態と実質的に同様に、本来、抑圧の必要の有る信号成分を抑圧できるので、ヌル点の形成を有効的に行うことができる。従って、SMI方式のアダプティブアンテナの自由度の無駄な消費を抑え得る。

【0218】例えば、図22中 α に示すように、アンテナ素子11、12によって、指向性を形成することができる。

【0219】すなわち、内積信号 $W^* X(i)^*$ のうち所望弁別信号 MX は、抑圧されることなく、所望処理信号 BA 、 MX 以外の GI 外遅延信号は抑圧される。しかしながら、 GI 外遅延信号と所望処理信号 BA とが同一方向から受信されると、 GI 外遅延信号と所望処理信号 BA とは、共に抑圧される。このように、内積信号 $W^* X(i)^*$ のうち、所望弁別信号 MX は、抑圧されるのではなく残されるものの、所望処理信号 BA は、受信方向によっては抑圧されることがある。

【0220】さらに、アンテナウエイト w_1 、 w_2 の更新によって、内積信号 $W^* X(i)^*$ のうち、少なくとも所望弁別信号 MX の成分が残されて得られる。ここで、所望弁別信号 MX は、上述の如く、所望処理信号 B のうち、弁別信号 $X(i)^*$ との相関が最も大きい信号であるため、所望弁別信号 MX の成分が残されることにより、弁別信号 $X(i)^*$ のうち受信レベルの大きな信号が、所望弁別信号 MX の成分として得ることができる。従って、所望弁別信号 MX の成分の復調を良好に行うことができる。

【0221】なお、上記第11実施形態においては、FFT回路801、802を採用してSMI方式のアダプティブアンテナを構成して、FFT回路801、802は、それぞれ、受信OFDM信号 $x_1(i)$ をFFT処理し、このFFT処理された周波数軸上の信号に基づきアンテナウエイト w_1 、 w_2 を求める例につき説明したが、これに限らず、以下のようにしてもよい。

【0222】すなわち、FFT回路801、802を採用することなく、SMI方式のアダプティブアンテナを構成して、受信OFDM信号 $x_1(i)$ をFFT処理した周波数軸上の信号に代えて、時間軸上の受信OFDM信号 $x_1(i)$ を採用して、時間軸上の受信OFDM信号 $x_1(i)$ アンテナウエイト w_1 、 w_2 を求めるようにしてもよい。

(第11実施形態) 本第11実施形態では、図22に示

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すように、上記第10実施形態の示す構成に、ローパスフィルタ(LPF)1040、1041が追加されている。

【0223】図22において、ローパスフィルタ1040は、FFT回路801からの弁別信号 $ft_1(1) \sim ft_1(3)$ に基づき狭帯域の弁別信号 $LF_1 \{= ft_1(1), ft_1(2)\}$ を求める。これとともに、ローパスフィルタ1040は、FFT回路802からの弁別信号 $ft_2(1) \sim ft_2(3)$ に基づき狭帯域の弁別信号 $LF_2 \{= ft_2(1), ft_2(2)\}$ を求める。

【0224】これにより、ローパスフィルタ1040は、数式53に示す狭帯域の弁別信号 LF を出力することになる。すなわち、ローパスフィルタ1040は、弁別信号 $ft_1(1) \sim ft_1(3)$ 、 $ft_2(1) \sim ft_2(3)$ のうち、所定周波数帯域の成分だけを取り出すことにより、狭帯域の弁別信号 LF_1 、 LF_2 を出力する。

【0225】

【数53】

$$LF = \begin{bmatrix} LF_1 \\ LF_2 \end{bmatrix} = \begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \end{bmatrix}$$

【0226】また、ローパスフィルタ1041は、FFT回路83及び位相回転器1000の間に接続されて、FFT回路83からの所望弁別信号 $rf_1(1)$ 、 $rf_1(2)$ 、 $rf_1(3)$ に基づき狭帯域の弁別信号 $rLF \{= rf_1(1), rf_1(2)\}$ を求める。すなわち、ローパスフィルタ1041は、所望弁別信号 $rf_1(1)$ 、 $rf_1(2)$ 、 $rf_1(3)$ のうち、所定周波数帯域の成分だけを取り出すことにより、狭帯域の弁別信号 $rf_1(1)$ 、 $rf_1(2)$ を出力する。

【0227】次に、位相回転器1000は、所望弁別信号 $rf_1(1)$ を4種の位相量(0° 、 θ° 、 $2\theta^\circ$ 、 $3\theta^\circ$)だけ回転処理して、この回転処理された所望弁別信号 $rf_1(1-\theta)$ 、 $rf_1(1-2\theta)$ 、 $rf_1(1-3\theta)$ と、所望弁別信号 $rf_1(1)$ とを出力する。

【0228】さらに、位相回転器1000は、所望弁別信号 $rf_1(2)$ を4種の位相量(0° 、 θ° 、 $2\theta^\circ$ 、 $3\theta^\circ$)だけ回転処理して、この回転処理された所望弁別信号 $rf_1(2-\theta)$ 、 $rf_1(2-2\theta)$ 、 $rf_1(2-3\theta)$ と、所望弁別信号 $rf_1(2)$ とを出力する。

【0229】なお、以下、所望弁別信号 $rf_1(1) \sim rf_1(1-3\theta)$ 、 $rf_1(2) \sim rf_1(2-3\theta)$ を、数式54に示すように、所望処理信号 LBS とする。

【0230】

【数54】

$$LBS = \begin{bmatrix} rf_1(1) & rf_1(2) \\ rf_1(1-\theta) & rf_1(2-\theta) \\ rf_1(1-2\theta) & rf_1(2-2\theta) \\ rf_1(1-3\theta) & rf_1(2-3\theta) \end{bmatrix}$$

【0231】次に、本第11実施形態の相関器1010は、上記第10実施形態で述べた所望処理信号 BS に代わる所望処理信号 LBS と、弁別信号 $X(i)'$ に代わる狭帯域の弁別信号 rLF との相関値 K' を求める。また、選択回路1020は、上記第10実施形態と実質的に同様に、相関値 K' に基づいて、所望処理信号 LBS のうち、狭帯域の弁別信号 rLF との相関が最も大きい周波数毎の所望弁別信号 MX' を求める。さらに、所望処理信号 LBS のうち、所望処理信号 MX' 以外の所望処理信号 BA' を求める。

【0232】次に、演算器1030では、弁別信号 $X(i)'$ に代えて狭帯域の弁別信号 rLF が入力されて、所望処理信号 MX に代えて所望処理信号 MX' が入力されるとともに、所望処理信号 BA に代えて所望処理信号 BA' が入力される。

【0233】そこで、相関行列推定器1031は、相関ベクトル推定器1033及び逆行行列演算器1032とともに、上記第10実施形態と実質的に同様に、狭帯域の弁別信号 rLF と所望処理信号 MX' とに基づいて相関行列の推定値 R_{xxxx} を求めるとともに、相関行列の推定値 R_{xxxx} の逆行行列 R_{xxxx}^{-1} を求める。

【0234】また、相関ベクトル推定器1033は、上記第10実施形態と実質的に同様に、狭帯域の弁別信号 rLF 、所望弁別信号 MX' 、及び、所望弁別信号 BA' を用いて、相関ベクトル推定値 r_{xnb} を求める。さらに、行列乗算器1034によって、相関行列の推定値 R_{xxxx} と相関ベクトル推定値 r_{xnb} とが行列乗算されてアンテナウエイト w_1 、 w_2 が求められて乗算器201、202にそれぞれ出力される。

【0235】以上により、内積信号 $W^*X(i)'$ のうち、所望処理信号 BA と所望弁別信号 MX とを除く成分が抑圧されるため、上記第10実施形態と実質的に同様の効果が得られる。さらに、内積信号 $W^*X(i)'$ のうち、少なくとも所望弁別信号 MX' の成分が残されて得られるため、上記第10実施形態と実質的に同様に、所望弁別信号 MX の成分の復調を良好に行うことができる。

【0236】また、相関器1010の相関値の演算にあたり、所望処理信号 BS に代えて所望処理信号 LBS が採用されるとともに、弁別信号 $X(i)'$ に代えて狭帯域の弁別信号 rLF が採用される。ここで、所望処理信号 LBS は、上述の如く、所望処理信号 BS に比べて周波数領域が狭く、狭帯域の弁別信号 rLF は、上述の如く、弁別信号 $X(i)'$ に比べて周波数領域が狭い。こ

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のため、相関器1010の相関値の演算量を、上記第10実施形態に比べて、減らすことができる。

【0237】さらに、選択回路1020が所望処理信号MX'BA'を求めるにあたり、相関器1010の相関値K'と、所望処理信号LBSと、狭帯域の弁別信号rLFとを採用するので、選択回路1020の演算量を、上記第10実施形態に比べて、減らすことができる。

【0238】また、演算器1030がアンテナウエイト w_1 、 w_2 を求めるにあたり、弁別信号 $X(i)'$ に代えて狭帯域の弁別信号rLFが採用されるとともに、所望処理信号MXに代えて所望処理信号MX'が採用される。このため、演算器1030の演算量を、上記第10実施形態に比べて、減らすことができる。

(第12実施形態)本第12実施形態では、上記第11実施形態で述べたローパスフィルタ(LPF)1040、1041を採用して、PI方式のアダプティブアレーアンテナを構成する例につき説明する。この場合の構成を、図23に示す。

【0239】本第12実施形態における、PI方式のアダプティブアレーアンテナは、アンテナ素子11、12、発生器60、FFT回路83、801、802、乗算器201、202、加算器(Σ)300、位相回転器1000、ローパスフィルタ(LPF)1040、1041、演算器1030Aから構成されている。演算器1030Aは、相関行列推定器1031A、逆行列演算器1032A、行列乗算器1034Aを有する。なお、図23において、図1、図2、図22中の同一符号は、同一物を示す。

【0240】まず、ローパスフィルタ1040は、上記第11実施形態と同様に、FFT回路801からの弁別信号 $ft_1(1) \sim ft_1(3)$ に基づき狭帯域の弁別信号 $LF_1 = \{ft_1(1), ft_1(2)\}$ を求めるとともに、FFT回路802からの弁別信号 $ft_2(1) \sim ft_2(3)$ に基づき狭帯域の弁別信号 $LF_2 = \{ft_2(1), ft_2(2)\}$ を求める。

【0241】次に、位相回転器1000は、上記第11実施形態と同様に、ローパスフィルタ1041からの狭帯域の弁別信号rLF $\{=rf_1(1), rf_1(2)\}$ に基づいて、数式53に示す所望処理信号LBSを求める。

【0242】次に、演算器1030Aにおいて相関行列推定器1031Aは、狭帯域の弁別信号 LF_1 、 LF_2 と所望処理信号LBSとを併せて、数式55に示す行列FBを生成するとともに、上記第10実施形態と実質的に、行列FBにおける、相関行列の推定値 $R_{f,f}$ を求める。

【0243】

【数55】

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$$FB = \begin{bmatrix} LF_1 \\ LF_2 \\ LBS \end{bmatrix} = \begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \\ rf_1(1) & rf_1(2) \\ rf_1(1\theta) & rf_1(2\theta) \\ rf_1(12\theta) & rf_1(22\theta) \\ rf_1(13\theta) & rf_1(23\theta) \end{bmatrix}$$

【0244】次に、逆行列演算器1032Aは、相関行列の推定値 $R_{f,f}$ の逆行列 $R_{f,f}^{-1}$ を求める。さらに、行列乗算器1034Aは、数式56に示す式を用いて、乗算結果 Z' を求めるとともに、乗算結果 Z' のうち、アンテナウエイト w_1 、 w_2 を乗算器201、202にそれぞれ出力する。なお、数式55中、 $-a_1$ 、 $-a_2$ 、 $-a_3$ 、 $-a_4$ は、上記第9実施形態に述べた信号ウエイト A である。

【0245】ここで、アンテナウエイト w_1 、 w_2 は、加算回路300の内積信号 $W^*X(i)'$ のうち、所望処理信号LBSを除く成分の電力を最小にするように更新される。

【0246】

【数56】

$$Z' = [1 \ 0 \ 0 \ 0]^T \times R_{f,f}^{-1} \\ = [w_1^* \ w_2^* \ -a_1 \ -a_2 \ -a_3 \ -a_4]^T$$

さらに、演算器1030Aは、アンテナウエイト w_1 、 w_2 を求めるにあたり、狭帯域の弁別信号rLFが採用されるとともに、所望処理信号LBSが採用される。ここで、狭帯域の弁別信号rLFの周波数帯域は、上記第10実施形態で述べた弁別信号 $X(i)'$ の周波数帯域に比べて狭く、所望処理信号LBSの周波数帯域は、上記第10実施形態で述べた所望処理信号BSの周波数帯域に比べて、狭い。従って、演算器1030Aは、弁別信号 $X(i)'$ と所望処理信号BSとを用いたときに比べて、演算量を減らすことができる。

【0247】なお、本発明の実施にあたり、アンテナ素子の数としては、2個以上であれば、幾らでもよい。

【0248】さらに、上記各実施形態では、各種信号を周波数弁別するにあたり、FFT処理を採用した例について説明したが、これに限らず、DFT処理等の各種の周波数弁別処理を採用してもよい。

40 【図面の簡単な説明】

【図1】本発明の第1実施形態のMMSE方式のアダプティブアレーアンテナの構成を示す図である。

【図2】上記第1実施形態のMMSE方式のアダプティブアレーアンテナのシュミレーションの結果を示す図である。

【図3】本発明の第2実施形態のMMSE方式のアダプティブアレーアンテナの構成を示す図である。

【図4】図3に示す遅延回路の詳細構成を示す図である。

50 【図5】本発明の第3実施形態のMMSE方式のアダプ

ティブアレーアンテナの構成を示す図である。

【図6】図5に示すFFT回路の詳細構成を示す図である。

【図7】図5に示す遅延回路の動作を示す図である。

【図8】図6に示すFFT回路の動作を示す図である。

【図9】本発明の第4実施形態のMMSE方式のアダプティブアレーアンテナの構成を示す図である。

【図10】図9に示すマッチドフィルタ及び遅延回路の動作を示す図である。

【図11】本発明の第5実施形態のMMSE方式のアダプティブアレーアンテナの構成を示す図である。

【図12】図11に示す所望信号選択回路の詳細構成を示す図である。

【図13】本発明の第6実施形態のMMSE方式のアダプティブアレーアンテナの構成を示す図である。

【図14】図13に示す等価回路の詳細構成を示す図である。

【図15】図14に示す等価回路の動作を示す図である。

【図16】本発明の第7実施形態のPI方式のアダプティブアレーアンテナの構成を示す図である。

【図17】上記第7実施形態のPI方式のアダプティブアレーアンテナのシュミレーションの結果を示す図であ

＊る。

【図18】本発明の第8実施形態のPI方式のアダプティブアレーアンテナの構成を示す図である。

【図19】図18のLPFの動作を示す図である。

【図20】本発明の第9実施形態のPI方式のアダプティブアレーアンテナの構成を示す図である。

【図21】本発明の第10実施形態のSMI方式のアダプティブアレーアンテナの構成を示す図である。

【図22】上記第10実施形態の動作を説明するための図である。

【図23】本発明の第11実施形態のSMI方式のアダプティブアレーアンテナの構成を示す図である。

【図24】本発明の第11実施形態のPI方式のアダプティブアレーアンテナの構成を示す図である。

【図25】OFDM信号のフォーマットを示す図である。

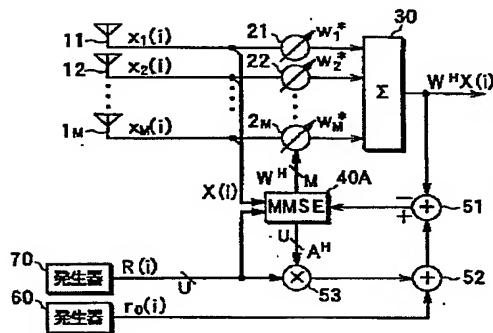
【図26】MMSE方式のアダプティブアレーアンテナの受信信号を説明するための図である。

【図27】従来のMMSE方式のアダプティブアレーアンテナの構成を示す図である。

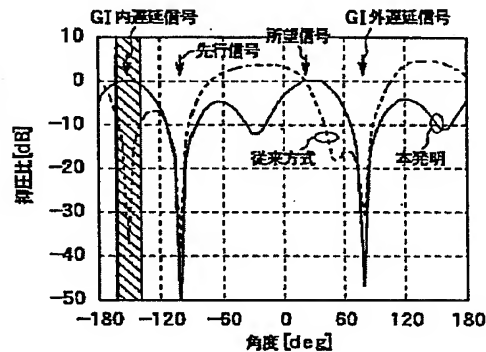
【符号の説明】

40A…MMSE演算器、30、51、52…加算器、60、70…発生器。

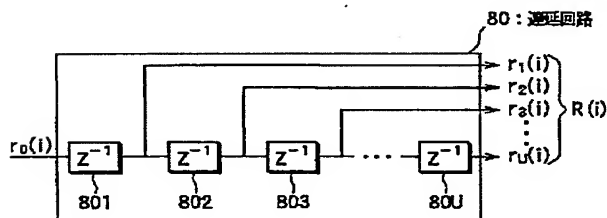
【図1】



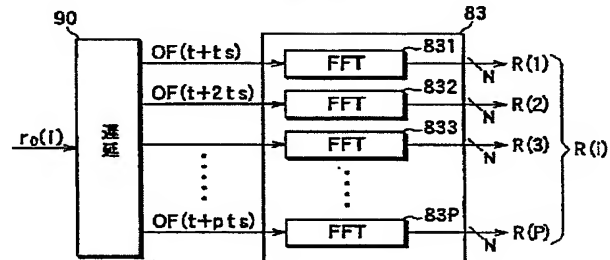
【図2】



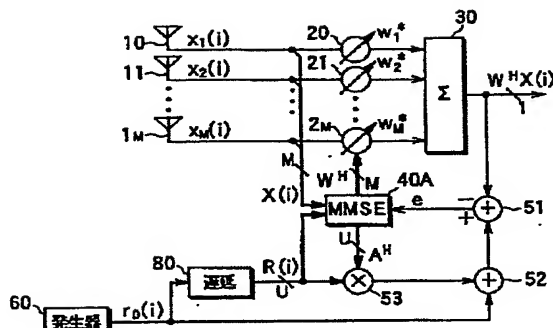
【図4】



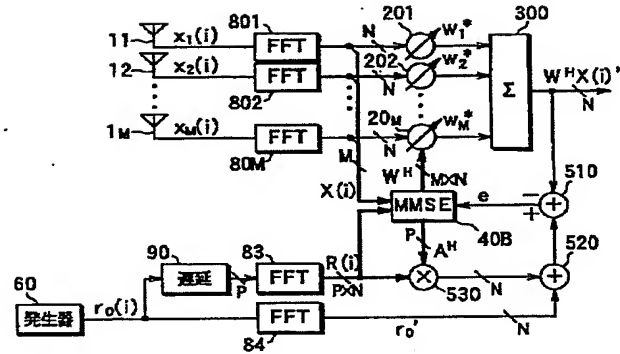
【図6】



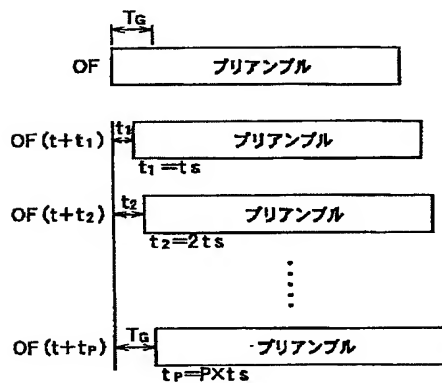
【図3】



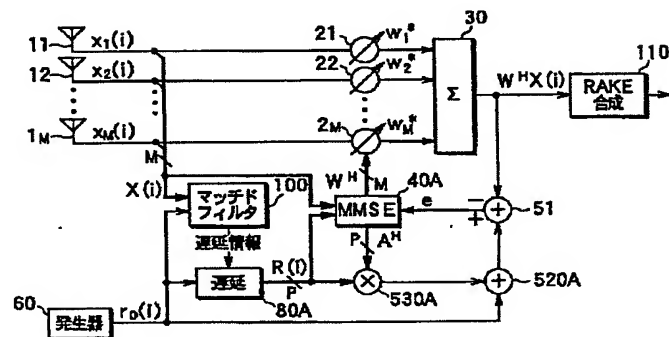
【図5】



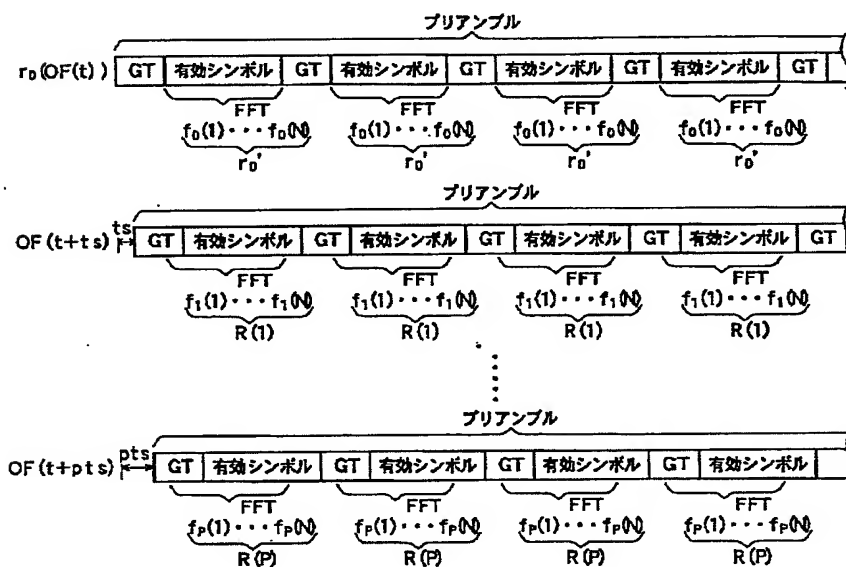
【図7】



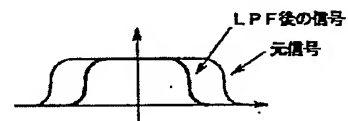
【図9】



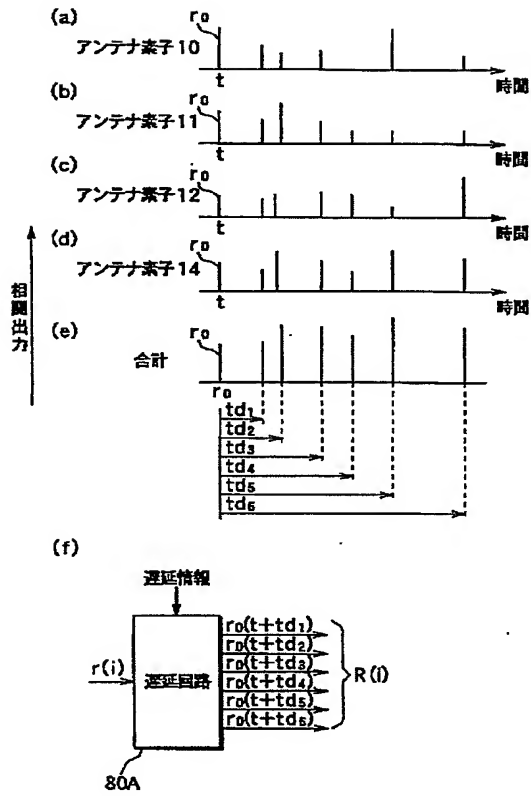
【図8】



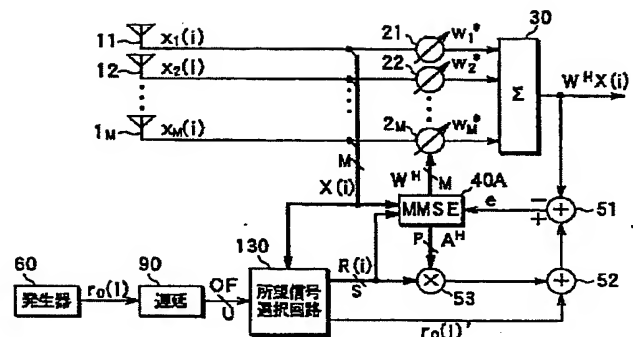
【図19】



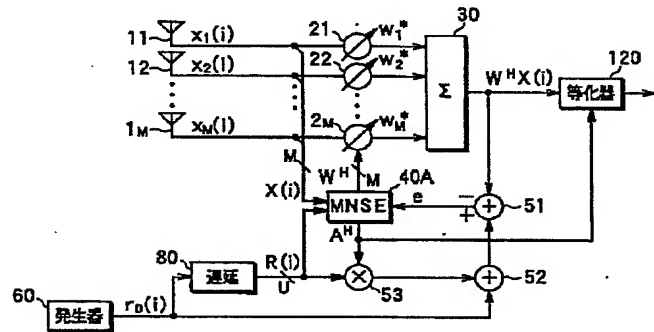
【図10】



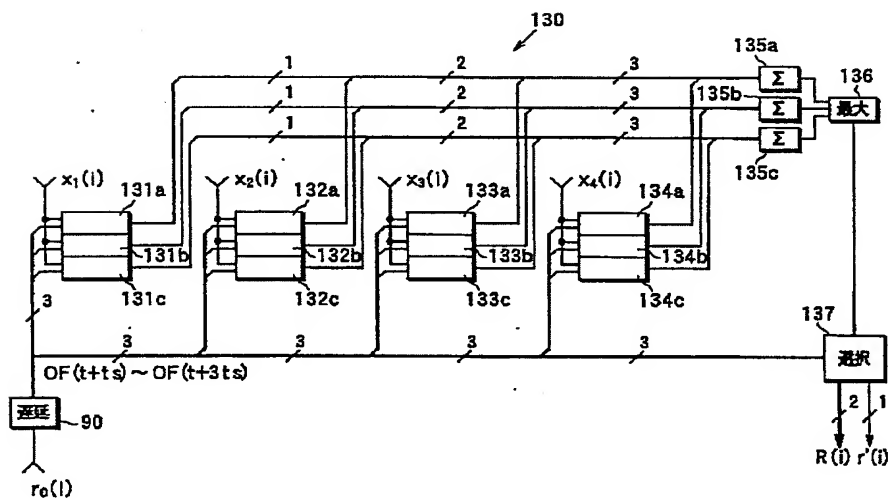
【図11】



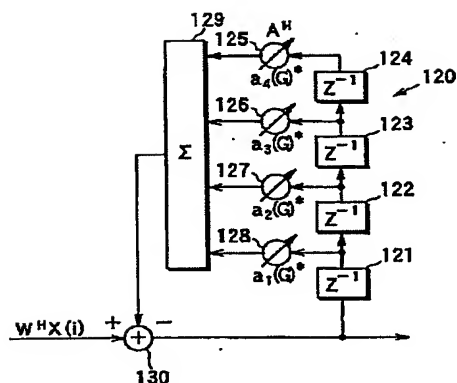
【図13】



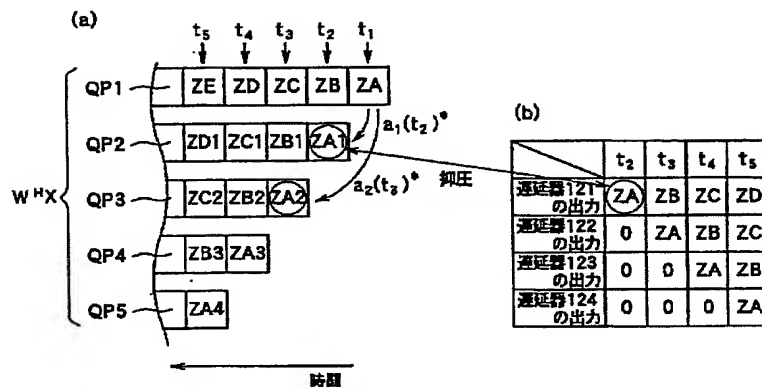
【図12】



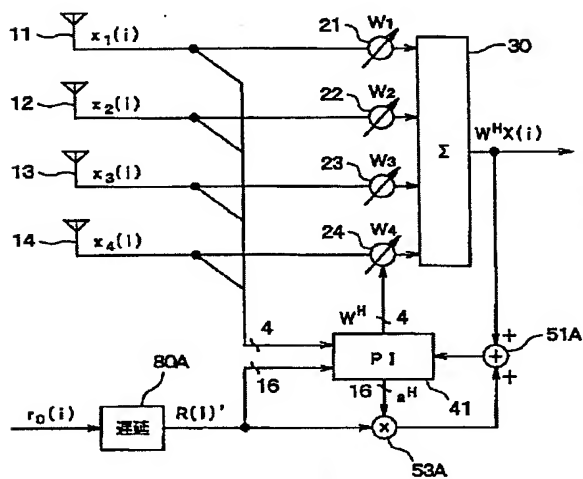
【圖 14】



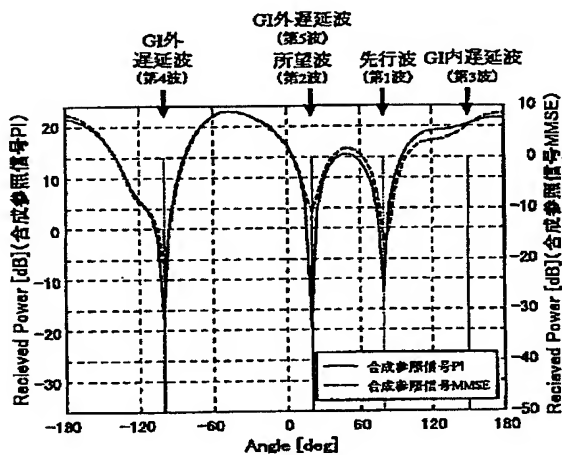
【図 15】



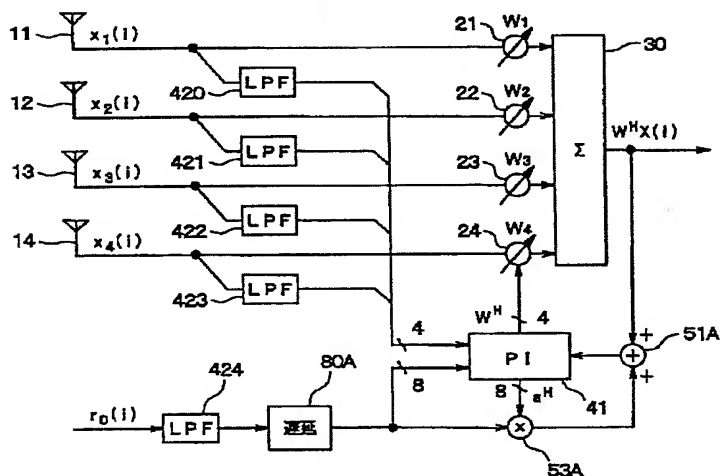
【圖 16】



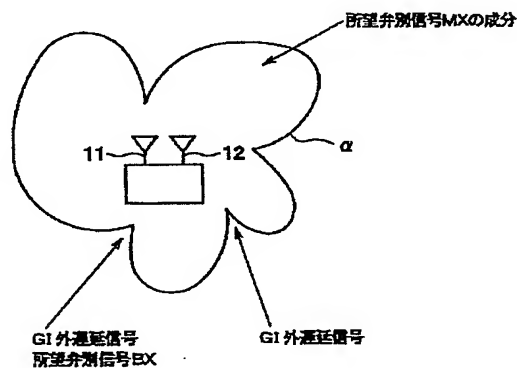
【圖 17】



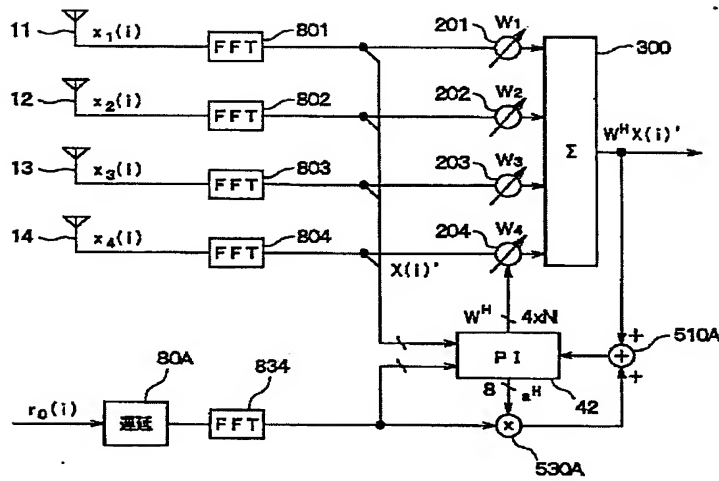
【圖 18】



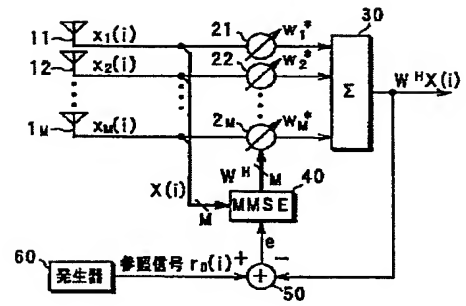
【圖22】



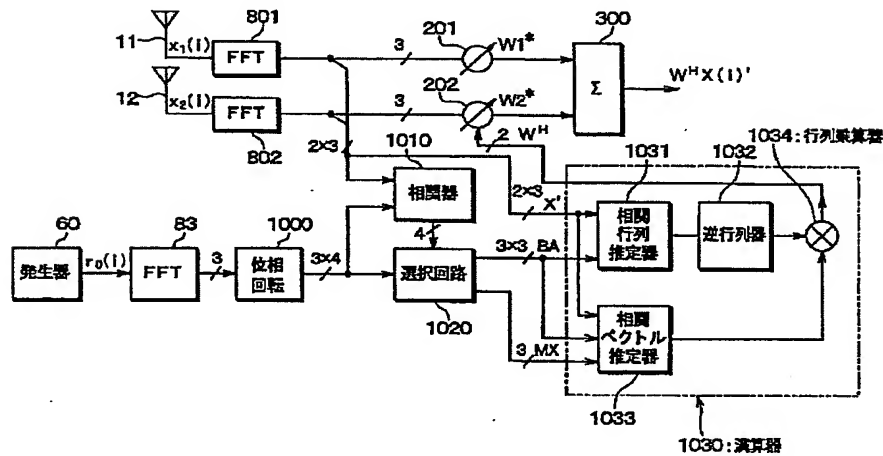
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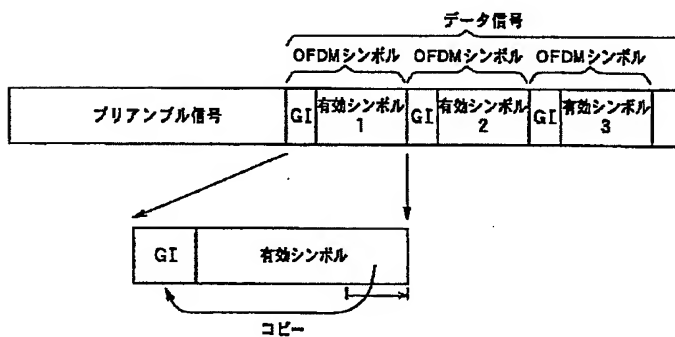
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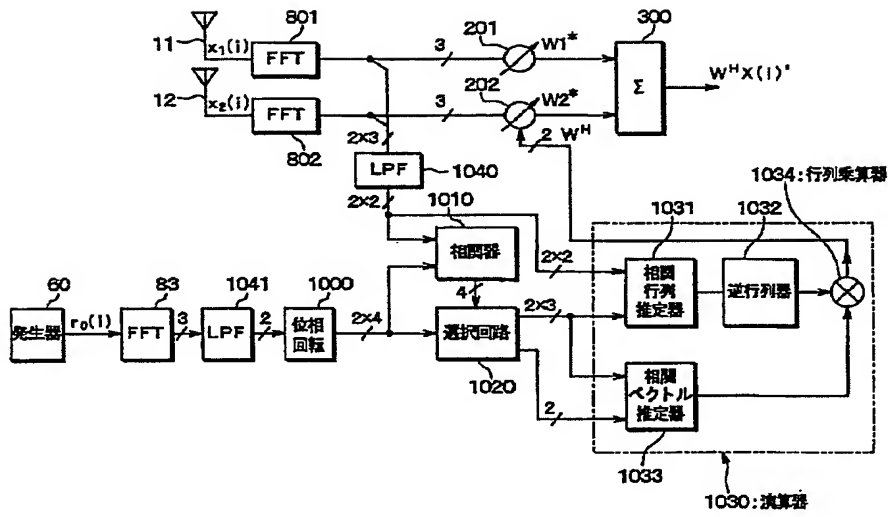
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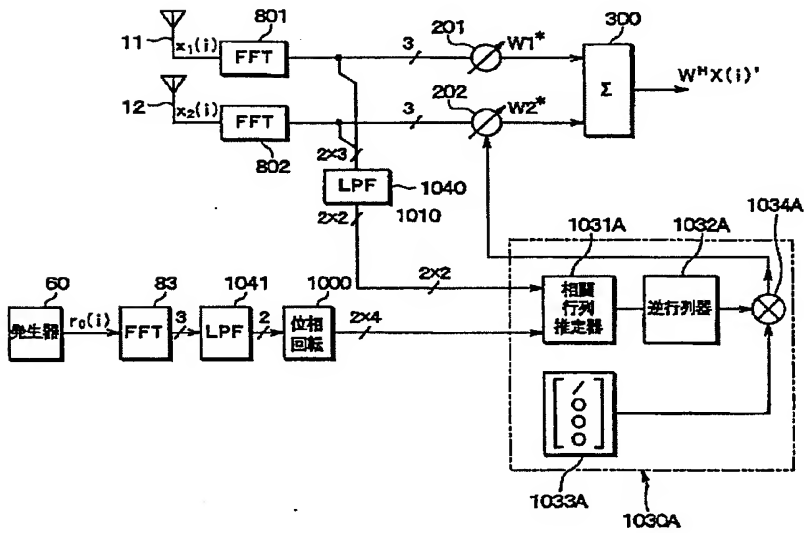
【図25】



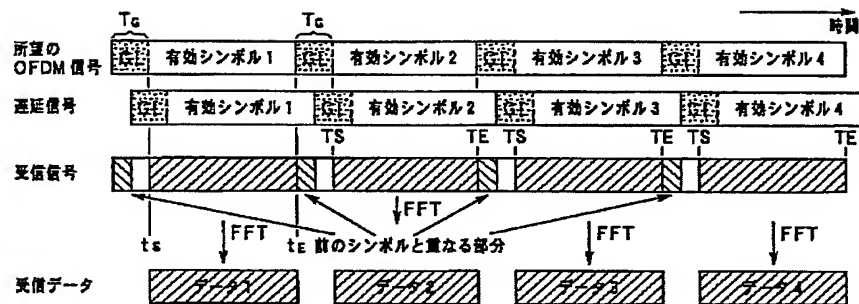
【図23】



【図24】



【図26】



フロントページの続き

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JAPANESE [JP,2002-359513,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART TECHNICAL PROBLEM
MEANS DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

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CLAIMS

[Claim(s)]

[Claim 1] The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by two or more antenna elements (11 — 1M) and said two or more antenna elements (21 — 2M), An addition means by which said antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A reference-sign calculation means to ask for a reference sign from the 1st known signal and the 2nd known signal (51-53, 51A, 53A), The adaptive array antenna characterized by having an updating means (40A, 41) to update said antenna weight according to the input signal received by said two or more antenna elements, said addition signal, and said reference sign.

[Claim 2] Said 2nd known signal is an adaptive array antenna according to claim 1 characterized by being the delay signal which carried out predetermined period delay to said 1st known signal.

[Claim 3] The adaptive array antenna according to claim 2 characterized by having said delay means (80) to carry out predetermined period delay and to search for said 2nd known signal for said 1st known signal.

[Claim 4] Said two or more antenna elements receive the signal which has the component of said 1st known signal, and the component of said 2nd known signal as said input signal, respectively. Based on the input signal received by said two or more antenna elements, it has a time delay calculation means (100) to find the time delay of the component of the 2nd [to the component of said 1st known signal / said] known signal. Said delay means is an adaptive array antenna according to claim 2 characterized by only for said time delay delaying said request known signal, and searching for said 2nd known signal.

[Claim 5] A delay signal generation means by which only time amount which is different to said 1st known signal, respectively generates two or more delay signals for ***** (90), The correlating detector which performs correlation detection of said two or more delay signals and said input signal (131a-134c), The adaptive array antenna according to claim 2 characterized by having a selection means (135a-136) to choose any of two or more of said delay signals they are as said 2nd known signal based on the correlation detection of said correlating detector.

[Claim 6] Said reference-sign calculation means is equipped with the weight multiplication section (53) which carries out the multiplication of the signal weight to said 2nd known signal. This signal weight adds said 1st known signal to said 2nd known signal by which multiplication was carried out, and it asks for said reference sign. Said updating means It is the adaptive array antenna of any one publication among claims 1-5 characterized by updating said signal weight according to the input signal received by said two or more antenna elements, the 2nd [said] known signal, said reference sign, and said addition signal.

[Claim 7] An oppression means to add a return signal in order to oppress the component of said 2nd known signal among the addition signals of said addition means (129 130), An addition signal delay means only for a predetermined period to delay said addition signal and to generate a delay addition signal (121-124), The adaptive array antenna according to claim 6 characterized by having a multiplication means (125-128) to carry out the multiplication of said signal weight to said delay addition signal, and to ask for said return signal.

[Claim 8] A received frequency discrimination means to carry out frequency discrimination of the

receiving OFDM signal received by two or more antenna elements (11 — 1M) and said two or more antenna elements, respectively, and to search for a discrimination signal (801-80M), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201-20M), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A request frequency judgment means to search for the request discrimination signal with which frequency discrimination of the request OFDM signal was carried out (84), A delay means to search for the delayed discrimination signal delayed to said request discrimination signal (90 83), A reference addition means to add said request discrimination signal to said delayed discrimination signal with which the multiplication of the signal weight was carried out to said delayed discrimination signal, and the multiplication of this signal weight was carried out, and to ask for a reference sign (510, 520, 530), According to each of said discrimination signal and said delayed discrimination signal, said addition signal is brought close to said reference sign. The adaptive array antenna characterized by having an updating means (40B) to update said antenna weight and said signal weight so that the component except the both sides of said request discrimination signal and a delayed discrimination signal may be oppressed among said each discrimination signal.

[Claim 9] A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements (11-14) and said two or more antenna elements, respectively, and to search for a discrimination signal (801-804), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201-204), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A delay means to search for the delay OFDM signal which carried out predetermined period delay to the request OFDM signal (80A), A request frequency judgment means by which the both sides of said request OFDM signal and said delay OFDM signal search for the request discrimination signal by which frequency discrimination was carried out (834), A reference addition means to carry out the multiplication of the signal weight to said request discrimination signal, and to ask for a reference sign (530A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (510A), The adaptive array antenna characterized by having an updating means (42) to update said antenna weight and said signal weight so that power of the component except the component of said request discrimination signal may be made small among said addition reference signs.

[Claim 10] The adaptive array antenna according to claim 8 or 9 characterized by having a generation means (60) to generate the preamble signal with which the known signal was arranged on the frequency shaft as said request OFDM signal.

[Claim 11] It is the adaptive array antenna according to claim 10 which said received frequency discrimination means carries out the thump rig of said receiving OFDM signal, acquires each sampling signal, searches for said discrimination signal according to said each sampling signal, and is characterized by said time delay being the predetermined multiple of the period of said sampling.

[Claim 12] Said delay means is the adaptive array antenna of any one publication of claim 8-11 characterized by outputting said delayed discrimination signal of the request number.

[Claim 13] The request number of said delayed discrimination signal is an adaptive array antenna according to claim 12 characterized by the guard interval period of the data signal of said request OFDM signal, the period of said sampling, and being the maximum number it is decided be alike.

[Claim 14] A means for said reference-sign calculation means to carry out the multiplication of the signal weight to said 1st and 2nd known signals, and to ask for said reference sign (53A), It has a means (51A) to add said reference sign and said addition signal, and to ask for an addition reference sign. Said updating means (41) The adaptive array antenna according to claim 2 or 3 characterized by updating said antenna weight and said signal weight so that power of the component except said 1st and 2nd known signals may be made small among said addition

reference signs.

[Claim 15] The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by two or more antenna elements (11-14) and said two or more antenna elements (21-24), An addition means by which said antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A received signalling frequency output means to output the received signalling frequency which shows the component of a narrow frequency band compared with the frequency band of these input signals among the input signals received by said two or more antenna elements, respectively (420-423), A known signalling frequency output means to output the known signalling frequency which shows the component of said narrow frequency band among known signals (424), A delay means to search for the delay signalling frequency which carried out predetermined period delay to said known signalling frequency (80A), A reference-sign calculation means to carry out the multiplication of the signal weight to said delay signalling frequency and said known signalling frequency, and to ask for a reference sign (53A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (51A), The adaptive array antenna characterized by having an updating means (41) to update said antenna weight and said signal weight so that power of the component except said delay signalling frequency and said known signalling frequency may be made small among said addition reference signs.

[Claim 16] A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements (11 12) and said two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A known frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A phase revolution means only for each amount of phases to carry out a phase revolution to said known discrimination signal, and to search for the phase revolution known discrimination signal corresponding to said each amount of phases (1000), A correlation means to take correlation with the phase revolution known discrimination signal corresponding to said each amount of phases, and said each discrimination signal, and to calculate the correlation value corresponding to said each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to said each amount of phases the phase revolution known discrimination signal corresponding to said each amount of phases — with a selection means (1020) to choose the response phase revolution known discrimination signal corresponding to said maximum correlation value inside While making small the component except the phase revolution known discrimination signal corresponding to said each amount of phases among said addition signals The adaptive array antenna characterized by having an updating means (1034) to update said antenna weight so that it may leave said response phase revolution known discrimination signal at least among said addition signals.

[Claim 17] A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements (11 12) and said two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among said each discrimination signal compared with said discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among said known

discrimination signals compared with said known discrimination signal (1041), Only the amount of phases which is different to said narrow-band known discrimination signal, respectively carries out a phase revolution. A phase revolution means to search for the signal according to phase rotary valve of the narrow-band corresponding to said each amount of phases (1000), A correlation means to take correlation with the signal according to phase rotary valve of the narrow-band corresponding to said each amount of phases, and said each discrimination signal, and to calculate the correlation value corresponding to said each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to said each amount of phases A selection means to choose the signal according to phase rotary valve of the narrow-band corresponding to said maximum correlation value among the signals according to phase rotary valve of each of said narrow-band (1020), While making small the component except the phase revolution known discrimination signal of the narrow-band corresponding to said each amount of phases among said addition signals The adaptive array antenna characterized by having an updating means (1033) to update said antenna weight so that it may leave the signal according to phase rotary valve of said corresponding narrow-band at least among said addition signals.

[Claim 18] A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements (11 12) and said two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among said each discrimination signal compared with said discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among said known discrimination signals compared with said known discrimination signal (1041), The phase revolution means which carries out the phase revolution of said narrow-band known discrimination signal (1000), The adaptive array antenna characterized by having an updating means (1030A) to update said antenna weight so that power of the component except said narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out may be made small among said addition signals.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to an adaptive array antenna.

[0002]

[Description of the Prior Art] In recent years, the various proposals of the adaptive array antenna of the MMSE method which receives the input signal of a rectangular cross multi-carrier method are made. First, the outline of the signal (the signal of a rectangular cross multi-carrier method is hereafter called OFDM signal) of a rectangular cross multi-carrier method is explained with reference to drawing 25 and drawing 26.

[0003] As shown in drawing 25, the OFDM signal consists of a data signal and a preamble signal before this data signal. A preamble signal is a signal which arranged two or more pilot symbols (known signal) on the frequency shaft. A data signal consists of two or more OFDM symbols by which time multiplied was carried out, and an OFDM symbol consists of a guard interval GI before an effective symbol and this effective symbol.

[0004] the guard interval GI — an effective symbol — the predetermined period part on [inner] the backside is copied. Therefore, if the time delay of the delay signal over a desired OFDM signal is shorter than the period TG of the guard interval GI when the sum of a desired OFDM signal and a desired delay signal is received as an input signal as shown in drawing 26, data (for example, QPSK symbol) can restore an input signal by FFT processing (frequency discrimination processing).

[0005] Next, the adaptive array antenna of an MMSE (Minimum Mean Square Error) method is explained with reference to drawing 23. Drawing 27 shows the outline configuration of the adaptive array antenna of an MMSE method. The adaptive array antenna of an MMSE method is an antenna element 11. — They are 1M and a multiplier 21. — It consists of 2M, the adder (sigma) 30, an MMSE computing element 40, an adder 50, and a generator 60. In addition, M is the natural number.

[0006] Antenna element 11 — 1M receive an OFDM signal through an electric wave, and output the receiving OFDM signal X (i), respectively. Here, the receiving OFDM signal X (i) can be expressed with a formula 1. T shows transposition. i shows time of day.

[0007]

[Equation 1]

$X(i) = [x_1(i) \ x_2(i) \ \dots \ x_M(i)]^T$ — T — this sake — antenna element 11 — 1M — respectively — the receiving OFDM signal $x_1(i)$, $x_2(i)$, and $x_M(i)$ is outputted. Moreover, the MMSE computing elements 50 are multipliers 21 and 22. — Multiplication is carried out to each of 2M at the antenna weight WH.

[0008] Here, the antenna weight WH can be expressed with a formula 2. H is complex-conjugate transposition.

[0009]

[Equation 2] A multiplier 20 carries out the multiplication of the receiving OFDM signal $x_1(i)$ to antenna weight w_1^* , and outputs a multiplication signal ($w_1^*x_1(i)$), and a multiplier 21 carries out the multiplication of the receiving OFDM signal $x_2(i)$ to antenna weight w_2^* , and outputs a

multiplication signal ($w2 \times x2(i)$) to a $W = [w1 \ w2 \ \dots \ wM]^T$ concrete target. Multiplier 2M carry out the multiplication of the receiving OFDM signal $XM(i)$ to antenna weight wM^* , and output a multiplication signal ($wM \times xM(i)$).

[0010] An adder (sigma) 30 is a multiplication signal ($w1 \times x1(i)$) and a multiplication signal ($w2 \times x2(i)$). — The inner product signal $WHX(i)$ which shows the inner product of the antenna weight W and the receiving OFDM signal $X(i)$ is searched for by adding a multiplication signal ($wM \times xM(i)$). a generator 60 memorizes a reference sign $r0(i)$ beforehand, and outputs this reference sign $r0(i)$ to an adder 50, and an adder 50 asks for error [of a reference sign $r0(i)$ and the inner product signal $WHX(i)$] $e(i) = \{ -e(i) = r0(i) - WHX(i) \}$. The MMSE computing element 40 updates the antenna weight W so that this error $e(i)$ may be made small by considering the receiving OFDM signal $X(i)$ and error $e(i)$ as an input, and it is multipliers 21 and 22 about that antenna weight W . — It outputs to 2M.

[0011] Here, the delay signal except a request known signal etc. can be oppressed among the receiving OFDM signals $X(i)$ by adopting a request known signal (for example, preamble signal on a time-axis) as a reference sign $r0(i)$. Incidentally, in the adaptive array antenna of an MMSE method, the number of the known signals (null point) which can be oppressed is prescribed by the number of antenna elements, and it is (the number of antenna elements). — It is "1." Hereafter, the number of the known signals (null point) which can be oppressed is called degree of freedom.

[0012]

[Problem(s) to be Solved by the Invention] By the way, in the adaptive array antenna of an MMSE method, although the time delay of the delay signal over a request known signal can restore data (the data 1 in drawing 26 — data 4) from an input signal if it is shorter than the period TG of the guard interval GI when the sum of a request known signal and its delay signal is received as an input signal like ****, the delay signal (henceforth the delay signal in GI) concerned will be oppressed.

[0013] It becomes impossible thus, to compound two or more signals and to raise the receiving engine performance by there being no need of oppressing and oppressing the delay signal in GI which can be restored and compounded.

[0014] moreover, null [in / in order to oppress the delay signal in GI / an adaptive array antenna] — the delay signal delayed for the delay signal in GI since a point would be formed — like — original — null — the signal which should form a point — null — there is a problem of it becoming impossible to form a point. That is, the degree of freedom of an adaptive array antenna will be consumed vainly.

[0015] This invention aims at offering the adaptive array antenna which held down useless consumption of a degree of freedom in view of the above.

[0016]

[Means for Solving the Problem] In order to attain the above-mentioned object, this invention in invention according to claim 1 The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by two or more antenna elements (11 — 1M) and two or more antenna elements (21 — 2M), An addition means by which antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A reference calculation means to ask for a reference sign from the 1st known signal and the 2nd known signal (51-53, 51A, 53A), It is characterized by having an updating means (40A, 41) to update antenna weight according to the input signal, reference sign, and addition signal which were received by two or more antenna elements.

[0017] Here, a reference sign is computed from the 1st and 2nd known signals, and an updating means updates antenna weight according to a reference sign and the above-mentioned input signal concerned, the 2nd known signal, and an addition signal. For this reason, an updating means can oppress the component except the 1st and 2nd known signals by renewal of antenna weight among the input signals received by two or more antenna elements. Therefore, since oppression of the 2nd known signal is prevented and a signal component with the need for oppression can originally be oppressed when oppression of the 2nd known signal is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the

degree of freedom of an adaptive array antenna is held down.

[0018] Moreover, since the component except the 2nd known signal is oppressed among [1st] input signals, the composite signal of the 1st and 2nd known signals can be acquired among input signals. Here, like invention according to claim 2, the 2nd known signal can acquire a good recovery signal, when it is the delay signal which carried out predetermined period delay to said 1st known signal and gets over using the composite signal of the 1st and 2nd known signals compared with the case where it restores only to the 1st known signal.

[0019] Furthermore, you may make it have a delay means (80) to carry out predetermined period delay of the 1st known signal, and to search for the 2nd known signal like invention according to claim 3. Moreover, the 2nd known signal is not prepared beforehand but you may make it search for the 2nd known signal according to an input signal.

[0020] Like invention according to claim 4, namely, two or more antenna elements The signal which has the component of the 1st known signal and the component of the 2nd known signal is received as an input signal, respectively. Based on the input signal received by two or more antenna elements, it has a time delay calculation means (100) to find the time delay of the component of the 2nd [to the component of the 1st known signal] known signal, and only a time delay delays a request known signal and you may make it a delay means search for the 2nd known signal.

[0021] Furthermore, a delay signal generation means by which only time amount which is different to the 1st known signal, respectively generates two or more delay signals for ***** like invention according to claim 5 (90), You may make it have the correlating detector (131a-134c) which performs correlation detection of each delay signal of a delay signal generation means, and said input signal, and a selection means (135a-136) to choose any of two or more delay signals they are as 2nd known signal based on the correlation detection of a correlating detector.

[0022] Like invention according to claim 6, specifically a reference-sign calculation means The 1st known signal is added to the 2nd known signal with which the multiplication of the signal weight was carried out to the 2nd known signal, and the multiplication of this signal weight was carried out, and it asks for a reference sign. An updating means You may make it update signal weight according to the input signal and the 2nd known signal which were received by two or more antenna elements, a reference sign, and an addition signal.

[0023] An oppression means to add a return signal by invention according to claim 7 here in order to oppress the component of the known signal of [2nd] the addition signals of an addition means (129-130), It is characterized by having an addition signal delay means (121-124) only for a predetermined period to delay an addition signal and to generate a delay addition signal, and a multiplication means (125-128) to carry out the multiplication of said signal weight to a delay addition signal, and to ask for said return signal. Thereby, an oppression means oppresses the component of the 2nd known signal among addition signals, and can output only the component of the 1st known signal.

[0024] Two or more antenna elements [invention / according to claim 8] (11 -- 1M), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801-80M), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201-20M), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A request frequency judgment means to search for the request discrimination signal with which frequency discrimination of the request OFDM signal was carried out (84), A delay means to search for the delayed discrimination signal delayed to the request discrimination signal (90-93), A reference addition means to add a request discrimination signal to the delayed discrimination signal with which the multiplication of the signal weight was carried out to the delayed discrimination signal, and the multiplication of this signal weight was carried out, and to ask for a reference sign (510, 520, 530), According to each of said discrimination signal and said delayed discrimination signal, said addition signal is brought close to said reference sign. It is characterized by having an

updating means (40B) to update said antenna weight and said signal weight so that the component except the both sides of said request discrimination signal and a delayed discrimination signal may be oppressed among said each discrimination signal.

[0025] Thus, an updating means updates antenna weight and signal weight so that the component except the both sides of a request discrimination signal and a delayed discrimination signal may be oppressed among each discrimination signal. For this reason, since oppression of a delayed discrimination signal is prevented and a signal component with the need for oppression can originally be oppressed when oppression of a delayed discrimination signal is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the degree of freedom of an adaptive array antenna is held down.

[0026] Moreover, since an updating means updates antenna weight and signal weight so that the component except the both sides of a request discrimination signal and a delayed discrimination signal may be oppressed among each discrimination signal like ****, it can obtain the both sides of a request discrimination signal and a delayed discrimination signal among each discrimination signal. If it gets over using the both sides of such a request discrimination signal and a delayed discrimination signal, a good recovery signal will be acquired compared with the case where it gets over only by the request discrimination signal.

[0027] Two or more antenna elements [invention / according to claim 9] (11-14), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by said two or more antenna elements, respectively, and to search for a discrimination signal (801-804), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201-204), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A delay means to search for the delay OFDM signal which carried out predetermined period delay to the request OFDM signal (80A), A request frequency judgment means by which the both sides of said request OFDM signal and said delay OFDM signal search for the request discrimination signal by which frequency discrimination was carried out (834), A reference addition means to carry out the multiplication of the signal weight to said request discrimination signal, and to ask for a reference sign (530A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (510A), It is characterized by having an updating means (42) to update said antenna weight and said signal weight so that power of the component except said request discrimination signal may be made small among said addition reference signs.

[0028] Thus, since an updating means updates antenna weight and signal weight so that power of the component except the component of request discrimination ***** may be made small among addition reference signs, it can make small power of the component except the component of a request discrimination signal among addition reference signs. Therefore, while oppression of the signal with which oppression of a request discrimination signal is prevented, namely, frequency discrimination of the request OFDM signal was carried out is prevented, oppression of the signal with which frequency discrimination of the delay OFDM signal was carried out is prevented.

[0029] For this reason, since a signal component with the need for oppression can originally be oppressed when oppression of the signal with which frequency discrimination of the delay OFDM signal was carried out is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the degree of freedom of an adaptive array antenna is held down.

[0030] Moreover, you may make it have a generation means (60) to generate the preamble signal with which the known signal was arranged on the frequency shaft as said request OFDM signal like invention according to claim 10. Furthermore, like invention according to claim 11, a received frequency discrimination means may carry out the thump rig of the receiving OFDM signal, each sampling signal may be acquired, said discrimination signal may be searched for according to each sampling signal, and you may make it a time delay be the predetermined multiple of the period of a sampling.

[0031] Furthermore, in invention according to claim 12, a delay means is characterized by outputting one delayed discrimination signal and said delayed discrimination signal of the request number. Thereby, like invention according to claim 1, an updating means can update said each antenna weight and signal weight so that the component except said request discrimination signal and the delayed discrimination signal of the request number may be oppressed among said each discrimination signal.

[0032] Furthermore, in invention according to claim 13, the request number of a delayed discrimination signal is characterized by being the maximum number decided by the guard interval period of the data signal of a request OFDM signal, and the period of a sampling. Thereby, further, since oppression of many delayed discrimination signals can be prevented, useless consumption of the degree of freedom of an adaptive array antenna can be held down effectively. In addition, the maximum number of a delayed discrimination signal is $\{(\text{period of a guard interval period} / \text{sampling}) - 1\}$.

[0033] In invention according to claim 14, a reference-sign calculation means A means to carry out the multiplication of the signal weight to said 1st and 2nd known signals, and to ask for said reference sign (53A), It has a means (51A) to add said reference sign and said addition signal, and to ask for an addition reference sign. Said updating means (41) It is characterized by updating said antenna weight and said signal weight so that power of the component except said 1st and 2nd known signals may be made small among said addition reference signs.

[0034] Thus, since an updating means (41) updates antenna weight and signal weight so that power of the component except the 1st and 2nd known signals may be made small among addition reference signs, it can make small power of the component except the 1st and 2nd known signals among addition reference signs. For this reason, control of the 1st and 2nd known signals can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of the 2nd known signal is unnecessary, the Nur point can be formed in an effective target.

[0035] Two or more antenna elements [invention / according to claim 15] (11-14), The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by said two or more antenna elements (21-24), An addition means by which said antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A received signalling frequency output means to output the received signalling frequency which shows the component of a narrow frequency band compared with the frequency band of these input signals among the input signals received by said two or more antenna elements, respectively (420-423), A known signalling frequency output means to output the known signalling frequency which shows the component of said narrow frequency band among known signals (424), A delay means to search for the delay signalling frequency which carried out predetermined period delay to said known signalling frequency (80A), A reference-sign calculation means to carry out the multiplication of the signal weight to said delay signalling frequency and said known signalling frequency, and to ask for a reference sign (53A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (51A), It is characterized by having an updating means (41) to update said antenna weight and said signal weight so that power of the component except said delay signalling frequency and said known signalling frequency may be made small among said addition reference signs.

[0036] Thus, since an updating means updates antenna weight and signal weight so that power of the component except delay signalling frequency and known signalling frequency may be made small among addition reference signs, it can make small power of the component except delay signalling frequency and known signalling frequency among addition reference signs. For this reason, control of delay signalling frequency and known signalling frequency can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of delay signalling frequency is unnecessary, the Nur point can be formed in an effective target.

[0037] Here, the count of updating of antenna weight and signal weight is decided by the frequency band of an input signal, and since it replaces with an input signal in renewal of antenna

weight and signal weight and the known signalling frequency of a narrow frequency band is used for it like **** compared with the frequency band of an input signal, it can reduce the count of updating of antenna weight and signal weight.

[0038] Moreover, two or more antenna elements [invention / according to claim 16] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A known frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A phase revolution means only for each amount of phases to carry out a phase revolution to a known discrimination signal, and to search for the phase revolution known discrimination signal corresponding to each amount of phases (1000), A correlation means to take correlation with the phase revolution known discrimination signal corresponding to each amount of phases, and each discrimination signal, and to calculate the correlation value corresponding to each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to each amount of phases the phase revolution known discrimination signal corresponding to each amount of phases — with a selection means (1020) to choose the response phase revolution known discrimination signal corresponding to a maximum correlation value inside While making small the component except the phase revolution known discrimination signal corresponding to each amount of phases among addition signals, it is characterized by having an updating means (1034) to update antenna weight so that it may leave a response phase revolution known discrimination signal at least among addition signals.

[0039] Thus, an updating means updates the antenna weight which makes small the component except the phase revolution known discrimination signal corresponding to each amount of phases among addition signals. Therefore, the component except the phase revolution known discrimination signal corresponding to each amount of phases can be made small among addition signals. For this reason, control of the phase revolution known discrimination signal corresponding to each amount of phases can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of the phase revolution known discrimination signal corresponding to each amount of phases is unnecessary, the Nur point can be formed in an effective target.

[0040] Furthermore, an updating means updates antenna weight so that it may leave the response phase revolution known discrimination signal corresponding to a maximum correlation value at least among addition signals. Therefore, it can leave the response phase revolution known discrimination signal corresponding to a maximum correlation value at least among addition signals.

[0041] Here, since a response phase revolution known discrimination signal is equivalent to the phase revolution known discrimination signal of a maximum-electric-power value among the phase revolution known discrimination signals corresponding to each amount of phases, it can acquire the big revolution known discrimination signal of a received-power value by leaving a response phase revolution known discrimination signal.

[0042] Two or more antenna elements [invention / according to claim 17] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among each discrimination signal compared with a discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and

to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among known discrimination signals compared with a known discrimination signal (1041), Only the amount of phases which is different to a narrow-band known discrimination signal, respectively carries out a phase revolution. A phase revolution means to search for the signal according to phase rotary valve of the narrow-band corresponding to each amount of phases (1000), A correlation means to take correlation with the signal according to phase rotary valve of the narrow-band corresponding to each amount of phases, and each discrimination signal, and to calculate the correlation value corresponding to each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to each amount of phases A selection means to choose the signal according to phase rotary valve of the narrow-band corresponding to a maximum correlation value among the signals according to phase rotary valve of each narrow-band (1020), While making small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals, it is characterized by having an updating means (1033) to update so that it may leave at least the signal according to phase rotary valve of the narrow-band which corresponds among addition signals.

[0043] Thus, since an updating means updates the antenna weight which makes small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals, it can make small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals. For this reason, control of the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases is unnecessary, the Nur point can be formed in an effective target.

[0044] Furthermore, an updating means updates antenna weight so that it may leave the phase revolution known discrimination signal of the narrow-band corresponding to a maximum correlation value at least among addition signals. Therefore, it can leave the phase revolution known discrimination signal of the narrow-band corresponding to a maximum correlation value at least among addition signals.

[0045] Here, since said corresponding phase revolution known discrimination signal of a narrow-band is equivalent to the phase revolution known discrimination signal of a maximum-electric-power value among the phase revolution known discrimination signals corresponding to each amount of phases, it can acquire the big revolution known discrimination signal of a received-power value by leaving said corresponding phase revolution known discrimination signal of a narrow-band.

[0046] Here, since the signal according to phase rotary valve of a narrow-band is used when an updating means updates antenna weight, the amount of operations for updating can be reduced compared with invention according to claim 16.

[0047] Two or more antenna elements [invention / according to claim 18] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among each discrimination signal compared with a discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among known discrimination signals compared with a known discrimination signal (1041), The phase revolution

means (1000) which carries out the phase revolution of the narrow-band known discrimination signal, and the inside of an addition signal, It is characterized by having an updating means (1030A) to update antenna weight so that power of the component except a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out may be made small.

[0048] Thus, since antenna weight is updated so that power of the component except the narrow-band known discrimination signal by which the phase revolution was carried out with the narrow-band known discrimination signal among addition signals may be made small, power of the component except a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out can be made small among addition signals. For this reason, control of a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out is unnecessary, the Nur point can be formed in an effective target.

[0049] Here, since said narrow-band known discrimination signal by which the phase revolution was carried out and signal according to phase rotary valve of a narrow-band are used when an updating means computes antenna weight, the amount of operations for updating can be reduced.

[0050] Incidentally, the sign in the parenthesis of each above-mentioned means is an example which shows response relation with the concrete means of a publication to the operation gestalt mentioned later.

[0051]

[Embodiment of the Invention] (The 1st operation gestalt) The adaptive array antenna of the MMSE method which starts the 1st operation gestalt of this invention at drawing 1 is shown. In a **** 1 operation gestalt, the adaptive array antenna of an MMSE method shows the example which receives an OFDM signal. Drawing 1 is a block diagram about the outline configuration of the adaptive array antenna of an MMSE method. The adaptive array antenna of an MMSE method is an antenna element 11, as shown in drawing 1. — They are 1M (M is the natural number) and a multiplier 21. — It consists of 2M, an adder (sigma) 30, MMSE computing-element 40A, adders 51 and 52, a multiplier 53, and generators 60 and 70. In drawing 1, the same sign as the sign in drawing 18 shows the same object or a substantial same object.

[0052] A generator 60 generates the preamble signal r_0 of an OFDM signal (i) as a request known signal, and this preamble signal r_0 (i) is a signal with which two or more pilot symbols (known signal) were arranged on the frequency shaft.

[0053] A generator 70 generates the delay signal of U (U is the natural number) individual to the preamble signal r_0 (i) as other known signals, and U delay signals have a different time delay to a preamble signal, respectively. However, each time delay of U delay signals over a preamble signal is short compared with the period TG of the guard interval GI of an OFDM symbol, and is hereafter set to delay signal R (i) which shows U delay signals in a formula 3.

[0054]

[Equation 3]

$R = (r_1, r_2, \dots, r_U)$ — r_1 — one — r_2 — two — r_U — U — T — next — a multiplier — 53 — a formula — four — expressing — a signal — weight — AH — delay — a signal — R — (r_1, r_2, \dots, r_U) — multiplication — carrying out — a formula — five — being shown — multiplication — a signal — $\{AHR = (r_1, r_2, \dots, r_U)$ — outputting.

[0055]

[Equation 4] $A = [a_1, a_2, \dots, a_U]$ T [0056]

[Equation 5] $AHR(i) = a_1 \cdot r_1(i) + a_2 \cdot r_2(i) + \dots + a_U \cdot r_U(i)$

Next, an adder 52 adds the preamble signal r_0 (i) and the multiplication signal AHR (i), and outputs an addition signal ($r_0(i) + AHR(i)$). Here, an addition signal ($r_0(i) + AHR(i)$) turns into a composite signal (reference sign) of the preamble signal r_0 (i) and delay signal R (i). And an adder 51 asks for error [of an addition signal ($r_0(i) + AHR(i)$) and the inner product signal WHX of an

adder 30 (i)] e (i). Here, error e (i) can be expressed to a formula 6.

[0057]

[Equation 6] To $e(i) = r_0(i) + AHR(i) - WHX$, next MMSE computing-element 40A The receiving OFDM signal X (i), delay signal R (i), and error e (i) are inputted. MMSE computing-element 40A for example, SMI (Sample Matrix Inversion) of an MMSE method, while updating the antenna weight W and outputting to a multiplier 21 and 22 --2M so that error e (i) may be made small based on law The signal weight A is updated and it outputs to a multiplier 53 so that error e (i) may be made small based on the SMI method of an MMSE method.

[0058] Thereby, as an inner product signal WHX of an adder 30, the component except preamble signal r_0 (i), (request known signal), and delay signal R (i) (other known signals) becomes a repressed signal among the receiving OFDM signals X (i).

[0059] Here, the signal weight A is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of delay signal R (i) and a (the 2nd known signal) on the basis of the preamble signal r_0 (i) and (the 1st known signal).

[0060] Hereafter, the description of a **** 1 operation gestalt is described. First, the time delay of delay signal R (i) to the preamble signal r_0 can restore data (for example, QPSK data symbol) for the inner product signal WHX of an adder 30 by FFT processing (frequency discrimination), without oppressing delay signal R (i) among the receiving OFDM signals X (i) like ****, since it is short compared with the period TG of the guard interval GI.

[0061] That is, oppression of delay signal R (i) is unnecessary among the receiving OFDM signals X (i). So, with a **** 1 operation gestalt, a repressed signal is acquired for the component except the preamble signal r_0 (i) and the delay signal AHR (i) among the receiving OFDM signals X (i) as an inner product signal WHX of an adder 30 like ****.

[0062] For this reason, since oppression of delay signal R (i) is prevented and a signal component with the need for oppression can originally be oppressed, the Nur point can be formed in an effective target. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an MMSE method can be held down.

[0063] Moreover, since the addition signal ($r_0(i) + AHR(i)$) of the preamble signal r_0 (i) and delay signal R (i) is acquired, if it restores to this addition signal as an inner product signal WHX of an adder 30, a good recovery signal will be acquired compared with the case where it restores to the preamble signal r_0 (i).

[0064] Here, the result of a simulation is shown in drawing 2. An axis of abscissa is the receiving include angle [deg] of the received electric wave on the basis of the adaptive array antenna of an MMSE method among drawing 2, and an axis of ordinate is an oppression ratio (dB). The chain line shows the result of the simulation which used the adaptive array antenna of the conventional MMSE method. A continuous line shows the result of the simulation which used the adaptive array antenna of the MMSE method of a **** 1 operation gestalt.

[0065] Although the delay signal in GI is oppressed in the adaptive array antenna of the conventional MMSE method so that drawing 2 may show, oppression of the delay signal in GI is prevented in the adaptive array antenna of the MMSE method of a **** 1 operation gestalt. However, the delay signal in GI is a delay signal which has a short time delay compared with Period (guard interval GI) TG to a request signal (preamble signal r_0).

[0066] Below, the SMI algorithm of the MMSE method of MMSE computing-element 40A in a **** 1 operation gestalt is described. First, error e (i) shown in a formula 6 can be transformed, and error e (i) can be expressed like a formula 7.

[0067]

[Equation 7]

$$\begin{aligned} e(i) &= r_0(i) + R(i) A^a - W^a X \\ &= r_0(i) - \{W^a X - R(i) A^a\} \\ &= r_0(i) - Y^a Z(i) \end{aligned}$$

Y is the antenna weight W and weight including the both sides of the signal weight A here, as shown in a formula 8, and Z (i) is a signal including the both sides of the receiving OFDM signal X

(i) and delay signal R (i), as expressed to a formula 9.

[0068]

[Equation 8] $Y = [w_1 \ w_2 \ w_3 \ \dots \ w_M - a_1 - a_2 - a_3 \ \dots - a_U] \ T$ [0069]

[Equation 9] $Z = \frac{1}{M} \left[\frac{1}{M} \sum_{i=1}^M x_i^2 - \left(\frac{1}{M} \sum_{i=1}^M x_i \right)^2 \right] + \frac{1}{M} \sum_{i=1}^M x_i^2 - \left(\frac{1}{M} \sum_{i=1}^M x_i \right)^2$... $x_M - \left(\frac{1}{M} \sum_{i=1}^M x_i \right)^2$... $r - one - \left(\frac{1}{M} \sum_{i=1}^M r_i \right)^2$... $r - two - \left(\frac{1}{M} \sum_{i=1}^M r_i \right)^2$... $r - three - \left(\frac{1}{M} \sum_{i=1}^M r_i \right)^2$... $rU - \left(\frac{1}{M} \sum_{i=1}^M r_i \right)^2$... TSMI — an algorithm — an odor — a formula — ten — being shown — a performance index — Q — direct — minimizing . However, alpha is the weighting constant of $0 < \alpha \leq 1$.

[0070]

[Equation 10]

$$Q(i) = \sum_{i=1}^G \alpha^{G-i} |e(i)|^2$$

[0071] Furthermore, the gradient vector about the weight Y of a formula 7 is set with zero, and the least square of a performance index Q is obtained like a formula 11. This formula 11 shows the formula for updating weight Y (G). However, G is time amount (thump rig time amount), and G shows the count of updating of Weight Y (number of steps).

[0072]

[Equation 11]

$$Y(G) = B^{-1}(G) b(G)$$

[0073] Here, a formula 12 and a formula 13 are shown for B in a formula 11, and b.

[0074]

[Equation 12]

$$B = \sum_{i=1}^G \alpha^{G-i} Z(i) Z^H(i)$$

[0075]

[Equation 13]

$$b(G) = \sum_{i=1}^G \alpha^{G-i} Z(i) r_0^*(i)$$

[0076] (The 2nd operation gestalt) Although the example which adopted the generator 70 was explained with the above-mentioned 1st operation gestalt in order to generate delay signal R (i) and (U delay signals), you may make it generate delay signal R (i) using the preamble signal outputted not only from this but from the generator 60. The configuration in this case is shown in drawing 3 and drawing 4 .

[0077] Drawing 3 is the block diagram showing the configuration of the adaptive array antenna of the MMSE method of a **** 2 operation gestalt, and drawing 4 is drawing showing the detail of the delay circuit in drawing 3 (henceforth a delay circuit 80). With the **** 2 operation gestalt, as shown in drawing 3 , while the generator 60 shown in drawing 1 is deleted, the delay circuit 80 is adopted. In drawing 3 , the same sign as the sign in drawing 1 shows the same object or a substantial same object.

[0078] A delay circuit 80 is arranged between a generator 60 and a multiplier 53, and outputs delay signal R (i) stated with the above-mentioned 1st operation gestalt in response to the preamble signal outputted from the generator 60.

[0079] Specifically, a delay circuit 80 is the delay signal r1 (i) with which the series connection of the delay machines (Z-1) 801, 802, and 803 and the —80U is carried out, it is constituted, and the delay machines 801, 802, and 803 and —80U correspond, respectively as shown in drawing 4 , and r2 (i). — rU (i) is outputted to MMSE computing-element 40A and a multiplier 53. Other actuation and effectiveness are the same as the above-mentioned 1st operation gestalt.

[0080] (The 3rd operation gestalt) Although the adaptive array antenna of an MMSE method explained the example which adopted the pudding AMBURU signal of an OFDM signal as a signal on a time-axis with the above-mentioned 1st and 2nd operation gestalt, you may make it adopt

each discrimination signal which carried out FFT processing (frequency judgment) of the pudding bull signal of not only this but an OFDM signal. The configuration in this case is shown in drawing 5 - drawing 8 . It is ***** with which drawing 5 is drawing showing the configuration of the adaptive array antenna of a ***** 3 operation gestalt, and drawing 6 indicates the detail configuration of the FFT circuit 83 in drawing 5 to be. Drawing 7 is drawing showing actuation of the delay circuit 90 of drawing 5 , and drawing 8 is drawing showing actuation of the FFT circuit in drawing 6 .

[0081] With the ***** 3 operation gestalt, as shown in drawing 5 , MMSE arithmetic circuit 40B is replaced with and adopted as MMSE arithmetic circuit 40A in drawing 1 , and Multipliers 201-20M are replaced with and adopted as the multipliers 21-2M in drawing 1 . Multipliers 510-530 are replaced with and adopted as the multipliers 51-53 in drawing 1 . Furthermore, the FFT circuits 801-80M, and 83 and 84 are added. The FFT circuit 801 carries out FFT processing of the pudding AMBURU signal of the receiving OFDM signal x1 of an antenna element 11 (i). The FFT circuit 801 samples only N (N is the natural number) time as every [of the above-mentioned pudding AMBURU signal] effective symbol (refer to drawing 17) (analog to digital conversion), carries out FFT processing based on each sampling signal, and, specifically, is the discrimination signal ft1 for every frequency (1), and ft1 (2). -- ft1 (N) may be outputted. Here, they are the discrimination signal ft1 (1) and ft1 (2). -- ft1 (N) can be summarized and can be expressed with a formula 14. Moreover, N is the count of a sampling of the above-mentioned effective symbol, and is the point size of FFT of the above-mentioned effective symbol.

[0082]

[Equation 14] As substantially as the FFT circuit 801, similarly, the FT1(i) =[ft1(1) ft1(2) ft1(3) -- ft1 (N)] TFFT circuit 802 carries out FFT processing of the pudding AMBURU signal of the receiving OFDM signal x1 of an antenna element 11 (i), and is the discrimination signal ft2 for every frequency (1), and ft2 (2). -- ft2 (N) is outputted. Furthermore, the discrimination signal ft2 (1), ft2 (2) -- ft2 (N) is summarized and can be expressed with a formula 15.

[0083]

[Equation 15] FT2(i) =[ft2(1) ft2(2) ft2(3) --ft2 (N)] TFFT circuit 80M carry out FFT processing of the pudding AMBURU signal of the receiving OFDM signal xM of antenna element 1M (i) similarly substantially with the FFT circuit 801, and are the discrimination signal ftM for every frequency (1), and ftM (2). -- ftM (N) is outputted. Furthermore, the discrimination signal ftM (1), ftM (2) -- ftM (N) is summarized and can be expressed with a formula 16.

[0084]

[Equation 16] FTM(i) =[-- ftM(1) ftM(2) ftM(3) -- ftM (N) --] -- T -- here -- a ***** 3 operation gestalt -- FT1 (i), FT2 (i), and -- [0085] made into discrimination signal X (i)' as FTM (i) is summarized and it is shown in a formula 17

[Equation 17] X -- ((-- i --) -- ' -- = -- [-- FT -- one -- ((-- i --) -- -- FT -- two -- ((-- i --) -- -- FTM -- ((-- i --) --)] -- T -- next -- a multiplier -- 201 - 20 -- M -- the antenna weight WH -- discrimination signal X (i)' -- multiplication -- carrying out . That is, a multiplier 201 obtains a result (w1*FT1 (i)) in quest of the product of antenna weight w1* and FT1 (i). A multiplier 202 obtains a result (w2*FT2 (i)) in quest of the product of antenna weight w2* and FT2 (i). Furthermore, multiplier 20M obtain a result (wM*FTM (i)) in quest of the product of antenna weight wM* and FTM (i).

[0086] next -- an adder (sigma) -- 300 -- a multiplier -- 201 - 20 -- M -- depending -- a result (w1*FT1 (i)) -- ((-- w -- two -- * -- FT -- two -- ((-- i --) --) -- (wM*FTM (i)) -- a frequency -- every -- adding -- things -- an antenna -- weight -- W -- discrimination -- a signal -- X -- ((-- i --) -- ' -- an inner product -- being shown -- an inner product -- a signal -- WHX -- ((-- i --) -- ' -- asking .

[0087] Incidentally, as inner product signal WHX (i)', as shown in a formula 18, the inner product signal of the N individual fx1(1) fx2(2) --fxM(N) is packed. Furthermore, for example, fx1 (1) can express an inner product signal with a formula 19, and the inner product signal fx2 (2) can be expressed with a formula 20. Furthermore, the inner product signal fxM (N) can be expressed with a formula 21.

[0088]

[Equation 18] $WHX(i)' = [fx1(1) \text{ } fx2(2) \text{ } \dots \text{ } fxM(N)] \text{ } T$ [0089]

[Equation 19] $fx1(1) = w1* \text{ and } ft1(1) + w2*, \text{ } ft2(1) \text{ } \dots \text{ } wM*, \text{ } ftM(1)$

[0090]

[Equation 20] $fx2(2) = w1* \text{ and } ft1(2) + w2*, \text{ } ft2(2) \text{ } \dots \text{ } wM*, \text{ } ftM(2)$

[0091]

[Equation 21] $fxM(N) = w1* \text{ and } ft1(N) + w2*, \text{ } ft2(N) \text{ } \dots \text{ } wM*, \text{ } ftM(N)$

Next, delay circuits 90 are the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS) over this preamble signal r0 (i), in response to the fact that the preamble signal r0 of an OFDM signal (i) and the (request known signal) from a generator 60, as shown in drawing 6. — OF (t+p-tS) is generated.

[0092] However, tS is the time amount which shows the sampling period of the FFT circuits 801-80M, and (p+1) is the count of the sampling at the time of sampling the guard interval GI of an OFDM symbol by time amount tS.

[0093] Thereby, they are the delay preamble signals OF (t+tS) and OF (t+2, tS). — OF (t+p-tS) has a time delay shorter than the guard interval period TG to the preamble signal r0 (i), respectively. Furthermore, as the number of a delay preamble signal, it is the maximum number defined with the guard interval period TG and a sampling period tS {p=(TG/tS)-1}.

[0094] Here the delay preamble signal OF (t+tS) As shown in drawing 7, by the signal which delayed only time amount tS to the preamble signal r0 (i) the delay preamble signal OF (t+2, tS) It is the signal which delayed only time amount 2 tS to the preamble signal r0 (i), and the delay preamble signal OF (t+3, tS) is a signal which delayed only time amount 3 and tS to the preamble signal r0 (i). The delay preamble signal OF (t+p-tS) is a signal which delayed only time amount p-tS to the preamble signal r0 (i).

[0095] Next, the FFT circuits 83 are the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS) from a delay circuit 90, as shown in drawing 6. — Each effective symbol of OF (t+p-tS) is sampled with a sampling period tS in juxtaposition, and FFT processing is carried out by the sampling signal. Specifically, the FFT circuits 83 are the FFT processing sections 831, 832, and 833. — It has 83p, and as shown in drawing 8, the FFT processing section 831 carries out FFT processing of the effective symbol of the delay preamble signal OF (t+tS) with a sampling period tS, and outputs delayed discrimination signal R (1). However, delayed discrimination signal R (1) can be expressed with a formula 22. This delayed discrimination signal R (1) has a signal component for every frequency.

[0096]

[Equation 22] $R(1) = \text{---} \text{---} f1(1) \text{ } f1(2) \text{ } f1(3) \text{ } \dots \text{ } f1(N) \text{ } \text{---} \text{---} T$ — the FFT processing section 832 outputs delayed discrimination signal R (2) shown in a formula 23 again by carrying out FFT processing of the effective symbol of the delay preamble signal OF (t+2, tS) with a sampling period tS, as shown in drawing 8. This delayed discrimination signal R (2) has a signal component for every frequency. Furthermore, FFT processing section 83p outputs delayed discrimination signal R (p) shown in a formula 24 by carrying out FFT processing of the effective symbol of the delay preamble signal OF (t+p-tS) with a sampling period tS, as shown in drawing 8. Delayed discrimination signal R (p) has a signal component for every frequency.

[0097]

[Equation 23] $R \text{ } \text{---} \text{---} \text{two} \text{ } \text{---} \text{---} = \text{---} \text{---} f \text{ } \text{---} \text{two} \text{ } \text{---} \text{---} \text{one} \text{ } \text{---} \text{---} f \text{ } \text{---} \text{two} \text{ } \text{---} \text{---} \text{two} \text{ } \text{---} \text{---} f \text{ } \text{---} \text{two} \text{ } \text{---} \text{---} \text{three} \text{ } \text{---} \text{---} f \text{ } \text{---} \text{two} \text{ } \text{---} \text{---} N \text{ } \text{---} \text{---} T \text{ } \text{---} [\text{---} 0098 \text{ } \text{---}]$

[Equation 24] $R \text{ } \text{---} \text{---} p \text{ } \text{---} \text{---} = \text{---} \text{---} fp \text{ } \text{---} \text{---} \text{one} \text{ } \text{---} \text{---} fp \text{ } \text{---} \text{---} \text{two} \text{ } \text{---} \text{---} fp \text{ } \text{---} \text{---} \text{three} \text{ } \text{---} \text{---} fp \text{ } \text{---} \text{---} N \text{ } \text{---} \text{---} T$ — next — drawing 5 — being shown — FFT — a circuit — 84 — drawing 8 — being shown — as — the preamble signal r0 of the OFDM signal from a generator 60 (i) — (= — the effective symbol of OF (t)) is sampled with a sampling period tS, and FFT processing is carried out by these sampling signal. Thereby, the FFT circuit 84 outputs request discrimination signal r0 (i)', as shown in a formula 25. Request discrimination signal r0 (i)' has a signal component for every frequency.

[0099]

[Equation 25] $r \text{ } \text{---} \text{---} \text{zero} \text{ } \text{---} \text{---} i \text{ } \text{---} \text{---} ' \text{ } \text{---} \text{---} = \text{---} \text{---} f \text{ } \text{---} \text{zero} \text{ } \text{---} \text{---} \text{one} \text{ } \text{---} \text{---} f \text{ } \text{---} \text{zero} \text{ } \text{---} \text{---} \text{two} \text{ } \text{---} \text{---} f \text{ } \text{---} \text{zero} \text{ } \text{---} \text{---} \text{three} \text{ } \text{---} \text{---} f \text{ } \text{---} \text{zero} \text{ } \text{---} \text{---} N \text{ } \text{---} \text{---} T$ — next — a

multiplier — 530 — the product of the signal weight AH and delayed discrimination signal $R(i)$ — taking — an output signal $\{AHR(i)\}$ — outputting. However, the signal weight A in a **** 3 operation gestalt is shown in a formula 26. In addition, an output signal $\{AHR(i)\}$ packs the output signal of N individual, and is written.

[0100]

[Equation 26] An adder 520 adds the output signal $\{AHR(i)\}$ of a multiplier 530, and request discrimination signal $r0(i)'$ to an $A=[a1 \ a2 \ \dots \ aP]$ T pan, and outputs an addition signal $(r0(i)'+AHR(i))$ to it. An adder 510 asks for error [with addition signal $(r0(i)'+AHR(i))$ and inner product signal / of an adder 30 / $WHX(i)'$] $e(i)$.

[0101] Here, to MMSE computing-element 40B, discrimination signal $X(i)'$, and delayed discrimination signal $R(i)$ and error $e(i)$ are inputted, and MMSE computing-element 40B updates the signal weight A while updating the antenna weight W like the above-mentioned 1st and 2nd operation gestalt so that error $e(i)$ may be made small based on the SMI method of an MMSE method. Thereby, as inner product signal [of an adder 300] $WHX(i)'$, the component except request discrimination signal $r0(i)'$ (request known signal) and delayed discrimination signal $R(i)$ (other known signals) becomes a repressed signal among discrimination signal $X(i)'$. Thereby, the same effectiveness is substantially acquired with the above-mentioned 1st and 2nd operation gestalt.

[0102] In addition, at the above-mentioned 3rd operation gestalt, they are the delay preamble signals $OF(t+tS)$, $OF(t+2, tS)$, and $OF(t+3, tS)$. — Although the example which obtained delayed discrimination signal $R(i)$ based on $OF(t+p-tS)$ was explained, delayed discrimination signal $R(i)$ may be obtained not only based on this but based on request discrimination signal $r0(i)'$.

[0103] (The 4th operation gestalt) Although the adaptive array antenna of an MMSE method explained the example which receives an OFDM signal with the above-mentioned 1-3rd operation gestalt, the adaptive array antenna of not only this but an MMSE method may be applied to a CDMA communication link. The configuration in this case is shown in drawing 9.

[0104] The matched filter 100 and the RAKE composition machine 110 are added and constituted from drawing 9 by the circuit shown in drawing 3. Furthermore, it replaces with the delay circuit 80 shown in drawing 3, and delay circuit 80A is adopted. In drawing 9, the same sign as the sign in drawing 1 shows the same object or a substantial same object. however — each — ANTENANA component 11 — 1M — an OFDM signal — replacing with — a CDMA signal — receiving — the receiving CDMA signal $x1(i)$, $x2(i)$, and — $xM(i)$ is outputted.

[0105] Next, actuation of a **** 4 operation gestalt is explained with reference to drawing 10. Hereafter, four antenna elements 11-14 are adopted, and the example to which antenna elements 11-14 output each is explained. A matched filter 100 performs correlation detection with the pilot signal (known signal) $(i) r0$ from each and a generator 60 for the receiving CDMA signal $x1(i)$, $x2(i)$, $x3(i)$, and $x4(i)$ in juxtaposition.

[0106] concrete — a matched filter 100 — the 1- it has the 4th matched filter section (not shown). The 1st matched filter section carries out correlation detection of the receiving CDMA signal $x1(i)$ and a pilot signal $r0(i)$, and outputs a correlation signal (refer to drawing 10 (a)), and the 2nd matched filter section considers correlation detection with a pilot signal $r0(i)$ as receiving CDMA signal $x2(i)$, and outputs a correlation signal (refer to drawing 10 (b)).

[0107] The 3rd matched filter section carries out correlation detection of the receiving CDMA signal $x3(i)$ and a pilot signal $r0(i)$, and outputs a correlation signal (refer to drawing 10 (c)), and the 4th matched filter section carries out correlation detection of the receiving CDMA signal $x4(i)$ and a pilot signal $r0(i)$, and outputs a correlation signal (refer to drawing 10 (d)). However, by drawing 10 (a) - (d), an axis of ordinate shows a correlation value, and an axis of abscissa shows time amount by it.

[0108] here — a matched filter 100 — the 1- the correlation signal from the 4th matched filter section is added, and the delay information on the basis of the time of the input of a pilot signal $r0(i)$ and a (request signal) is acquired based on the addition result. This delay information shows the delay signal of a time delay shorter than desired time amount among receiving CDMA signal $x1(i) - x4(i)$. The example shown in drawing 10 (e) shows the example of ** from which $td1$, $td2$,

td3–td6 are obtained as delay information. Then, using the delay information td1–td6, delay circuit 80A outputs delay signal R (i) and (other known signals), as shown in drawing 10 (f).

[0109] That is, delay circuit 80A is $r_0(t+td_1)$, $r_0(t+td_2)$, and $r_0(t+td_2)$. — $r_0(t+td_6)$ is outputted. For example, to a pilot signal $r_0(i)$, only the time delay td1 is delayed and, as for $r_0(t+td_2)$, only the time delay td2 is delayed by $r_0(t+td_1)$ to a pilot signal $r_0(i)$. As for $r_0(t+td_6)$, only the time delay td6 is delayed to a pilot signal $r_0(i)$. Other actuation is substantially [as the circuit shown in drawing 3] the same.

[0110] By the above, it is the receiving CDMA signal $x_1(i)$ as an inner product signal WHX from an adder (sigma). — A repressed signal is acquired for the component except a pilot signal $r_0(i)$ (request signal) and its delay signals $r_0(t+td_1)$ – $r_0(t+td_6)$ (other known signals) among $x_M(s)(i)$. And the RAKE composition machine 110 will perform a RAKE composition recovery using the inner product signal WHX concerned. if a signal required for a RAKE composition recovery is prepared here as delay signals $r_0(t+td_1)$ – $r_0(t+td_6)$ — an oppression of a signal unnecessary for a RAKE composition recovery sake — null — a point can be formed. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an MMSE method can be held down like the above-mentioned 1st operation gestalt.

[0111] In addition, the adaptive array antenna of an MMSE method is applied to the communication link of a CDMA method, and although the example which acquires the delay information on the CDMA input signal X (i) with a matched filter 100 was shown, you may make it acquire the delay information on the receiving OFDM signal of not only this but the above-mentioned 1st and 2nd operation gestalt with a matched filter 100 in the above-mentioned 4th operation gestalt.

[0112] (The 5th operation gestalt) Although the 2 above-mentioned operation gestalten explained the example which set up beforehand a request known signal and other known signal ****, you may make it choose a request known signal and other known signals among delay signal R (i) not only according to this but according to the receiving OFDM signal X (i).

[0113] The configuration in this case is shown in drawing 11 and drawing 12. Drawing 11 shows the configuration of the adaptive array antenna of the MMSE method in a **** 5 operation gestalt. Drawing 12 shows the detail configuration of the request signal selection circuitry in drawing 11 (following and request signal selection circuitry 130).

[0114] As the adaptive array antenna of the MMSE method of a **** 5 operation gestalt is shown in drawing 11, the request signal selection circuitry 130 is added to the circuit shown in drawing 3. In drawing 11, the same sign which drawing 3 shows shows the same object or a real target the same object.

[0115] A delay circuit 90 receives the preamble signal r_0 from a generator 60 (i), and is the delay preamble signals OF ($t+tS$) and OF ($t+2, tS$). — OF ($t+U-tS$) is generated. However, U is the delay preamble signal [as opposed to / are the natural number and / the preamble signal $r_0(i)$] OF ($t+tS$). — Each time delay of OF ($t+U-tS$) is short compared with the guard interval period TG of an OFDM signal.

[0116] the receiving OFDM signal X (i) and delay preamble signal OF($t+tS$) —OF ($t+U-tS$) input into the request signal selection circuitry 130 — having — the request signal selection circuitry 130 — the receiving OFDM signal X (i) — responding — delay preamble signal OF($t+tS$) — request known signal $r_0(i)$ and delay signal R (i) are chosen among OF(s) ($t+U-tS$).

[0117] Specifically, the request signal selection circuitry 130 consists of Correlators 131a–131c, 132a–132c, 133a–133c, 134a–134c, adders (sigma) 135a–135c, a maximum judging machine 136, and a selection circuitry 137, as shown in drawing 12.

[0118] Next, actuation of a **** 5 operation gestalt is explained with reference to drawing 12. The example which adopted only four antenna elements called antenna elements 11–14, and adopted three delay preamble signals of the delay preamble signals OF ($t+tS$), OF ($t+2, tS$), and OF ($t+3, tS$) hereafter is explained. First, antenna elements 11–14 output the receiving OFDM signal $x_1(i)$, $x_2(i)$, $x_3(i)$, and $x_4(i)$, respectively.

[0119] Next, correlator 131a performs correlation detection of the delay preamble signal OF ($t+tS$) and the receiving OFDM signal $x_1(i)$, and correlator 132a performs correlation detection of the delay preamble signal OF ($t+tS$) and receiving OFDM signal $x_2(i)$. Correlator 133a

performs correlation detection of the delay preamble signal OF ($t+tS$) and the receiving OFDM signal $x3(i)$, and correlator 134a performs correlation detection of the delay preamble signal OF ($t+tS$) and the receiving OFDM signal $x4(i)$.

[0120] Adder 135a adds the correlation detecting signal from each of Correlators 131a, 132a, 133a, and 134a, and outputs an addition signal. Here, the addition signal of adder 135a shows correlation with the delay preamble signal OF ($t+tS$), the receiving OFDM signal $x1(i)$, $x2(i)$, $x3(i)$, and $x4(i)$.

[0121] Next, correlator 131b performs correlation detection of the delay preamble signal OF ($t+2, tS$) and the receiving OFDM signal $x1(i)$, and correlator 132b performs correlation detection of the delay preamble signal OF ($t+2, tS$) and receiving OFDM signal $x2(i)$. Correlator 133b performs correlation detection of the delay preamble signal OF ($t+2, tS$) and the receiving OFDM signal $x3(i)$, and correlator 134b performs correlation detection of the delay preamble signal OF ($t+2, tS$) and the receiving OFDM signal $x4(i)$.

[0122] Adder 135b adds the correlation detecting signal from each of Correlators 131b, 132b, 133b, and 134b, and outputs an addition signal. The addition signal of adder 135b shows correlation with the delay preamble signal OF ($t+2, tS$), the receiving OFDM signal $x1(i)$, $x2(i)$, $x3(i)$, and $x4(i)$.

[0123] Next, correlator 131c performs correlation detection of the delay preamble signal OF ($t+3, tS$) and the receiving OFDM signal $x1(i)$, and correlator 132c performs correlation detection of the delay preamble signal OF ($t+3, tS$) and receiving OFDM signal $x2(i)$. Correlator 133c performs correlation detection of the delay preamble signal OF ($t+3, tS$) and the receiving OFDM signal $x3(i)$, and correlator 134c performs correlation detection of the delay preamble signal OF ($t+3, tS$) and the receiving OFDM signal $x4(i)$.

[0124] Adder 135c adds the correlation detecting signal from each of Correlators 131c, 132c, 133c, and 134c, and outputs an addition signal. The addition signal of adder 135c shows correlation with the delay preamble signal OF ($t+3, tS$), the receiving OFDM signal $x1(i)$, $x2(i)$, $x3(i)$, and $x4(i)$.

[0125] Next, the maximum judging machine 136 judges the addition signal (henceforth a maximum addition signal) which serves as maximum among each addition signal from Adders 135a-135c, and outputs the maximum recognition signal which shows this maximum addition signal to a selection circuitry 137. Among the delay preamble signals OF ($t+tS$), OF ($t+2, tS$), and OF ($t+3, tS$), a selection circuitry 137 chooses the delay preamble signal corresponding to a maximum recognition signal as request known signal $r(i)$, and outputs it. Furthermore, a selection circuitry 137 outputs two delay preamble signals except the delay preamble signal corresponding to a maximum recognition signal as other known signals $R(i)$ among the delay preamble signals OF ($t+tS$), OF ($t+2, tS$), and OF ($t+3, tS$). Other actuation is substantially [as the above-mentioned 2nd operation gestalt] the same.

[0126] In addition, in the above-mentioned 5th operation gestalt, although the example which adopted four antenna elements 11-14 was explained, if the number of not only this but an antenna element is two or more pieces, it is good without limit. Furthermore, although the above-mentioned 5th operation gestalt explained per [which adopted three delay preamble signals OF ($t+tS$), OF ($t+2, tS$), and OF ($t+3, tS$)] example, any number of numbers of not only this but a delay preamble signal are good.

[0127] In addition, as correlator shown in a **** 5 operation gestalt, various correlators, such as slide correlator and a matched filter, may be applied in operation of this invention.

[0128] (The 6th operation gestalt) With a **** 6 operation gestalt, the circuit where the equalizing circuit (henceforth an equalizing circuit 120) was added is adopted as the circuit of the above-mentioned 2nd operation gestalt, by the equalizing circuit 120, others and a known signal are oppressed among the inner product signals WHX of an adder 30 (i), and the repressed signal is outputted as an output signal. The configuration in this case is shown in drawing 13 and drawing 14.

[0129] Drawing 13 is drawing showing the configuration of the adaptive array antenna of the MMSE method of a **** 6 operation gestalt. Drawing 14 shows the detail configuration of the equalizing circuit 120 in drawing 13. In drawing 13, the same sign in drawing 3 shows the same

object or a real target the same object.

[0130] With the **** 6 operation gestalt, the adaptive array antenna of an MMSE method is applied to the QPSK communication mode instead of an OFDM communication mode. For this reason, antenna elements 11-1M receive a QPSK signal (pilot signal).

[0131] Therefore, antenna elements 11-1M are replaced with the receiving OFDM signal X (i), and output the receiving QPSK signal X (i), respectively. Moreover, the generating circuit 60 outputs the pilot signal r0 of a QPSK signal (i) as a request known signal, and a delay circuit 90 outputs delay pilot signal R (i) for which only the request period was delayed to the pilot signal r0 of a QPSK signal (i) as other known signals. MMSE computing-element 40A updates the antenna weight WH and the signal weight AH similarly substantially with the above-mentioned 2nd operation gestalt. Moreover, the component excluding [an adder (sigma) 30] the both sides of a request pilot signal (request known signal) and its delay pilot signal (other known signals) among the receiving QPSK signals X (i) outputs a repressed signal as an inner product signal WHX. Moreover, the equalizing circuit 120 consists of delay machines (Z-1) 121-124, multipliers 125-128, and adders 129 and 130, as shown in drawing 14 . Next, actuation of the equalizing circuit 120 of a **** 6 operation gestalt is explained with reference to drawing 14 and drawing 15 .

[0132] Hereafter, as shown in drawing 15 (a), the example as which total with request pilot signal QP1 and the delay pilot signals QP2-QP5 was adopted is explained as an inner product signal WHX of an adder (sigma) 30.

[0133] Since four delay pilot signals of the delay pilot signals QP2-QP5 are adopted here, the signal weight (henceforth signal weight A (G)) of MMSE computing-element 40A in a **** 6 operation gestalt can be expressed with a formula 27. G is sampling timing (updating timing) (G=t1, t2, t3 ---). Moreover, drawing 15 (b) shows the output of the delay machines 121-124 in timing t1-t5.

[0134]

[Equation 27] $A(G) = \frac{1}{T} [a_1(G) + a_2(G) + a_3(G) + a_4(G)]$ — T — the QPSK symbol ZA shown in drawing 15 (a) is first inputted into the delay machine 121 through an adder 130 to timing t1. That is, an equalizing circuit 120 can output the QPSK symbol ZA to timing t1.

[0135] Next, to timing t2, as shown in drawing 15 (b), the delay machine 121 outputs the QPSK symbol ZA to the delay machine 122 while outputting the QPSK symbol ZA to a multiplier 127. Then, a multiplier 128 carries out the multiplication of signal weight $a_1(t_2) *$ to the QPSK symbol ZA, and outputs a multiplication signal ($a_1(t_2) * ZA$) to an adder 129.

[0136] Here, as the above-mentioned 1st operation gestalt described, signal weight $a_1(t_2) *$ (signal weight AH) is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZA1 {delay signal R (i)} on the basis of the QPSK symbol ZA {the preamble signal r0 (i)}. For this reason, a multiplication signal ($a_1(t_2) * ZA$) becomes equal to the QPSK symbol ZA1 ($ZA1 = a_1(t_2) * ZA$).

[0137] Thereby, a multiplier 128 can output the multiplication signal ZA1 to an adder 130 through an adder 129. Moreover, the QPSK symbols ZB and ZA1 are inputted into an adder 130 as an inner product signal WHX of an adder (sigma) 30. An adder 130 outputs a differential signal (= ZB) to the delay machine 121 in quest of the difference of the QPSK symbols ZB and ZA1 and the multiplication signal ZA1. That is, an equalizing circuit 120 can output the QPSK symbol ZB to timing t2.

[0138] Next, to timing t3, the delay machine 122 outputs the QPSK symbol ZA to the delay machine 123 while outputting the QPSK symbol ZA to a multiplier 127, as shown in drawing 15 (b). Then, a multiplier 127 carries out the multiplication of signal weight $a_2(t_3) *$ to the QPSK symbol ZA, and outputs a multiplication signal ($a_2(t_3) * ZA$) to an adder 129.

[0139] Here, as the above-mentioned 1st operation gestalt described, signal weight $a_2(t_3) * ZA$ (signal weight AH) is calculated so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZA2 {delay signal R (i)} on the basis of the QPSK symbol ZA {the preamble signal r0 (i)}. For this reason, a multiplication signal ($a_2(t_3) * ZA$) becomes equal to the QPSK symbol ZA2 ($ZA2 = a_2(t_3) * ZA$). Therefore, a multiplier 127 outputs the QPSK symbol ZA2 to an adder 129.

[0140] Moreover, the delay machine 121 outputs the QPSK symbol ZB to the delay machine 122

while outputting the QPSK symbol ZB to a multiplier 128, as shown in drawing 15 (b). A multiplier 128 carries out the multiplication of signal weight $a_1(t_3) *$ to the QPSK symbol ZB, and outputs a multiplication signal $(a_1(t_3) * ZB)$ to an adder 129.

[0141] Here, as the above-mentioned 1st operation gestalt described, signal weight $a_1(t_3) *$ (signal weight AH) is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZB1 {delay signal R (i)} on the basis of the QPSK symbol ZB {the preamble signal r0 (i)}.

[0142] Therefore, a multiplication signal $(a_1(t_3) * ZB)$ becomes equal to the QPSK symbol ZB1 ($ZB1 = a_1(t_3) * ZB$). Therefore, a multiplier 127 can output the multiplication signal ZB1 to an adder 129.

[0143] Here, an adder 129 adds the multiplication signal ZB1 of a multiplier 127, and the QPSK symbol ZA2 of an adder 129, and outputs an addition signal $(ZB1 + ZA2)$ to an adder 130. The QPSK symbols ZC, ZB1, and ZA2 are inputted into an adder 130 as an inner product signal WHX of an adder (sigma) 30, and an adder 130 asks for the difference of the QPSK symbols ZC, ZB1, and ZA2 and an addition signal $(ZB1 + ZA2)$, and outputs a differential signal ZC to the delay machine 121.

[0144] That is, an equalizing circuit 120 can output the QPSK symbol ZC to timing t_3 . Hereafter, an equalizing circuit 120 operates similarly substantially with above-mentioned actuation, by timing t_4 , outputs the QPSK symbol ZD and outputs the QPSK symbol ZE to timing t_5 .

[0145] By the above, an equalizing circuit 120 can output only QPSK symbol ZA-ZD like ****. If it puts in another way, as an inner product signal WHX of an adder (sigma) 30, total with request pilot signal QP1 and the delay pilot signals QP2-QP5 will be inputted into an equalizing circuit 120, it will oppress the delay pilot signals QP2-QP5, and will output only request pilot signal QP1.

[0146] In addition, although the above-mentioned 6th operation gestalt explained the example which applied the adaptive array antenna of an MMSE method to the QPSK communication mode, you may apply not only to this but to an OFDM communication mode.

[0147] Furthermore, it is in charge of operation of this invention, and various communication modes may be adopted in addition to an OFDM communication mode, a CDMA communication mode, the communication mode using a QPSK modulation, etc.

[0148] In addition, although the 1st - the 6th operation gestalt explained the example which adopted the SMI algorithm of an MMSE method with the MMSE computing elements 40A and 40B, other algorithms may be adopted as long as it is an MMSE method.

[0149] When an interference wave comes from the same direction as a request signal in the (7th operation gestalt) and time in the adaptive array antenna of the MMSE method stated with the above-mentioned 1st operation gestalt, there is a problem that the interference wave cannot be oppressed. namely, in the adaptive array antenna of the MMSE method stated with the above-mentioned 1st operation gestalt Although the component except the preamble signal r0 (i) and delay signal R (i) becomes a repressed signal among the receiving OFDM signals X (i), the inner product signal WHX of an adder 30 When a delay-GI outside signal (interference wave) comes from the same direction as the preamble signal r0 (i), the GI delay signal can be controlled.

[0150] It is well-known to oppress without distinguishing the request signal and interference wave which are contained in it in an incoming wave component in the adaptive array antenna of the conventional PI method. Then, in a **** 7 operation gestalt, it explains per [oppresses the interference wave which accomplished paying attention to the adaptive array antenna of the conventional PI method, and prevents oppression of the both sides of a request wave and the delay signal in GI, and comes from the same direction as a request signal and it is made to raise the communication link engine performance] example. The configuration in this case is shown in drawing 16 .

[0151] The adaptive array antenna of PI method is antenna elements 11-14 and a multiplier 21. - It consists of 2M, an adder (sigma) 30, the PI computing element 41, adder 51A, multiplier 53A, and delay circuit 80A. In drawing 16 , the same sign as the sign in drawing 1 shows the same object or a substantial same object.

[0152] Delay circuit 80A outputs this preamble signal r0 (i) and delay signal R (i) in response to

the preamble signal $r_0(i)$ stated with the above-mentioned 1st operation gestalt. Hereafter, the output signal of delay circuit 80A is called output signal $R(i)'$.

[0153] However, like ****, the time delay of delay signal $R(i)$ to a preamble signal is short compared with the period TG of the guard interval GI of an OFDM symbol, and sets the number (sample point size) of delay signal $R(i)$ to 16.

[0154] Multiplier 53A carries out the multiplication of the signal weight AH to output signal $R(i)'$, and searches for a multiplication signal $\{AHR(i)'\}$. Adder 51A adds a multiplication signal $\{AHR(i)'\}$ and the inner product signal WHX of an adder 30 (i), and asks for an addition reference sign $(WHX(i)+AHR(i)')$.

[0155] Addition reference-sign $(WHX(i)+AHR(i)')$ and output signal $R(i)'$ and the receiving OFDM signal $X(i)$ are inputted into the PI computing element 41, and the PI computing element 41 updates the antenna weight W and the signal weight A so that power $|WHX(i)+AHR(i)'|^2$ of an addition reference sign may be made into min. At this time, the signal weight A turns into weight which negates output signal $R(i)'$ among the signal components contained in the inner product signal WHX (i), and the antenna weight W turns into weight which makes min power of the interference wave component contained in the receiving OFDM signal $X(i)$.

[0156] If it puts in another way, the PI computing element 41 will update the antenna weight W and the signal weight A so that power of the component except output signal $R(i)'$ may be made into min among the power $(WHX(i)+AHR(i)')$ of an addition reference sign.

[0157] In drawing 17, the result of a simulation when a request signal and a delay-GI outside signal come from the same is shown. In drawing 17, when the 1st – the 5th wave come, the directivity after actuation of the adaptive array antenna of the adaptive array antenna of PI method and an MMSE method is shown. The receiving include angle [deg] of the received [a right longitudinal shaft] electric wave on the basis of the adaptive array antenna of an MMSE method and a left-vertical shaft are the receiving include angles [deg] of the received electric wave on the basis of the adaptive array antenna of PI method. An axis of abscissa is an oppression ratio (dB).

[0158] In drawing 17, since antenna gain differs, it expresses with the adaptive array antenna of an MMSE method, and the adaptive array antenna of PI method that the gain of the direction of delay ***** in GI becomes the same.

[0159] Here, the chain line shows the result of the simulation which used the adaptive array antenna of an MMSE method. A continuous line shows the result of the simulation which used the adaptive array antenna of PI method. Although the delay-GI outside signal of the same direction as a request signal is not oppressed in the adaptive array antenna of an MMSE method so that drawing 17 may show, the delay-GI outside signal of the same direction as a request signal is oppressed in the adaptive array antenna of PI method.

[0160] (The 8th operation gestalt) With the **** 8 operation gestalt, as shown in drawing 18, low pass filters 420–425 are added to the configuration which the above-mentioned 7th operation gestalt shows. In drawing 18, low pass filters 420–424 search for the OFDM signal signal of a narrow-band based on the receiving OFDM signal $X(i)$.

[0161] Low pass filters 420–424 output a narrow-band OFDM signal signal by taking out only the component (referring to drawing 19) of the predetermined frequency band among the receiving OFDM signals $X(i)$. That is, the OFDM signal signal of a narrow-band turns into a signal which narrowed the frequency band of the receiving OFDM signal $X(i)$.

[0162] A low pass filter 425 searches for a narrow-band preamble signal based on the preamble signal $r_0(i)$. that is, the low pass filter 425 — the preamble signal $r_0(i)$ — a narrow-band preamble signal is outputted by taking out only the component of the predetermined frequency band inside.

[0163] In connection with this, delay circuit 80A searches for the delay signal of U (drawing 19 8) individual which has a different time delay to a narrow-band preamble signal, and outputs the both sides of this delay signal and a narrow-band preamble signal as output signal $R(i)'$. However, the time delay of the delay signal over a preamble signal is short like **** compared with the period TG of the guard interval GI of an OFDM symbol.

[0164] Here, among output signal $R(i)'$, the number of adoption of a delay signal (sample point)

can be reduced, if it is decided by the frequency band of the receiving OFDM signal $X(i)$ and the frequency band is narrowed.

[0165] then — **** — eight — operation — a gestalt — PI — a computing element — 41 — an antenna — weight — W — and — a signal — weight — A — updating — hitting — OFDM — a signal — a signal — replacing with — a narrow-band — OFDM — a signal — a signal — adopting — a preamble — a signal — having been based — an output signal — R — (i) — ' — replacing with — a narrow-band — a preamble — a signal — having been based — an output signal — R — (i) — ' — adopting . For this reason, not to mention reducing the number of adoption of $R(i)$, it becomes possible about the antenna weight W and the signal weight A to reduce the count of updating, and the computational complexity of renewal of weight can be reduced.

[0166] (The 9th operation gestalt) Although the above-mentioned 3rd operation gestalt explained the adaptive array antenna of the MMSE method which adopted the pudding AMBURU signal of an OFDM signal as a signal on a time-axis, a **** 9 operation gestalt explains per adaptive array antenna of PI method which adopted each discrimination signal which carried out FFT processing (frequency judgment) of the pudding bull signal of not only this but an OFDM signal. The configuration in this case is shown in drawing 20 .

[0167] The adaptive array antenna of PI method consists of antenna elements 11-14, a multiplier 201-204, an adder (sigma) 300, the FFT circuits 801-804, the FFT circuit 834, the PI computing element 42, adder 510A, multiplier 530A, and delay circuit 80A. In drawing 20 , the same sign as the sign in drawing 5 shows the same object.

[0168] As the above-mentioned 8th operation gestalt described, delay circuit 80A combines the preamble signal $r0(i)$ and delay signal $R(i)$, and outputs them as output signal $R(i)'$. The FFT circuit 834 samples each effective symbol of the preamble signal $r0(i)$ and delay signal $R(i)$ with a sampling period tS in juxtaposition, carries out FFT processing by the sampling signal, and outputs the discrimination signal $RFT(i)$.

[0169] Multiplier 530A carries out the multiplication of the signal weight AH to the discrimination signal $RFT(i)$, and searches for a multiplication signal $\{AHRFT(i)\}$. Adder 510A adds multiplication signal $\{AHRFT(i)\}$ and inner product signal [of an adder 300] $WHX(i)'$, and asks for an addition reference sign $(WHX(i)'+AHRFT(i))$.

[0170] Discrimination signal $X(i)'$, and an addition reference sign $(WHX(i)'+AHRFT(i))$ and the discrimination signal $RFT(i)$ are inputted into the PI computing element 42, and the PI computing element 42 updates the antenna weight W and the signal weight A so that power $|WHX(i)'+AHRFT(i)|^2$ of an addition reference sign may be made into min. At this time, the signal weight A turns into weight which negates the discrimination signal $RFT(i)$ among the signal components contained in inner product signal $WHX(i)'$, and the antenna weight W turns into weight which makes min power of the interference wave component contained in discrimination signal $X(i)'$.

[0171] If it puts in another way, the PI computing element 42 will update the antenna weight W and the signal weight A so that power of the component except the discrimination signal $RFT(i)$ may be made into min among addition reference signs $(WHX(i)'+AHRFT(i))$.

(The 10th operation gestalt) The adaptive array antenna of the SMI method in a **** 10 operation gestalt consists of antenna elements 11 and 12, a generator 60, the FFT circuits 83, 801, and 802, multipliers 201 and 202, an adder (sigma) 300, the phase revolution machine 1000, correlator 1010, a selection circuitry 1020, and a computing element 1030, as shown in drawing 21 .

[0172] A computing element 1030 has the matrix-of-correlation presumption machine 1031, the inverse-matrix computing element 1032, the correlation vector presumption machine 1033, and the matrix multiplication machine 1034. In addition, in drawing 21 , the same sign in drawing 1 and drawing 2 shows the same object.

[0173] First, FFT processing of the pudding AMBURU signal of the receiving OFDM signal $x1(i)$ received by the antenna element 11 is carried out in the FFT circuit 801, and the discrimination signal $ft1(1)$, $ft1(2)$, $ft1(3)$, and $ft1(4)$ are calculated for every frequency. Moreover, FFT processing of the receiving OFDM signal $x2(i)$ received by the antenna element 12 is carried out

in the FFT circuit 802, and the discrimination signal $ft2(1)$, $ft2(2)$, $ft2(3)$, and $ft2(4)$ are calculated for every frequency. In addition, the figure 1—4 in the parenthesis of a discrimination signal shows the point size of FFT.

[0174] Here, the vector notation of receiving OFDM signal $x1(i)$ $x2(i)$ discrimination signal $ft1(1) - ft1(3)$ and the discrimination signal $ft2(1) - ft2(3)$ is carried out as follows.

[0175]

[Equation 28] $X(i) = [x1(i) \ x2(i)]^T$ [0176]

[Equation 29] $FT1(i) = [ft1(1) \ ft1(2) \ ft1(3)]^T$ [0177]

[Equation 30] The $FT2(i) = [ft2(1) \ ft2(2) \ ft2(3)]^T$ multiplier 201 asks for the matrix product ($w1*FT1(i)$) of antenna weight $w1*$ and $FT1(i)$, and a multiplier 202 asks for the matrix product ($w2*FT2(i)$) of antenna weight $w2*$ and $FT2(i)$.

[0178] Next, an adder (sigma) 300 adds the matrix product ($w1*FT1(i)$) by multipliers 201 and 202, and ($w2*FT2(i)$) for every frequency. namely, — a matrix — a product ($w1*FT1(i)$) — (— w — two — * — FT — two — (— i —) —) — an antenna — weight — w — one — * — w — two — * — a formula — 31 — 32 — like — a vector — a notation — carrying out — if — an adder (sigma) — 300 — an antenna — weight — W — discrimination — a signal — X — (— i —) — ' — an inner product — being shown — an inner product — a signal — WHX — (— i —) — ' — asking — having. Moreover, as shown in a formula 33, the vector notation of inner product signal $WHX(i)'$ is carried out.

[0179]

[Equation 31]

$X(i)' = [FT1(i) \ FT2(i)]^T$ [0180]

[Equation 32] $W = [w1 \ w2]^T$ [0181]

[Equation 33] $WHX(i)' = [w1*ft1(1)+w2*ft2(1) \ w1*ft1(2)+w2*ft2(2) \ w1*ft1(3)+w2*ft2(3)]^T$ T, next a generator 60 as a request known signal Generating the preamble signal $r0$ of an OFDM signal (i), this preamble signal $r0(i)$ is a signal with which two or more pilot symbols (known signal) were arranged on the frequency shaft. Moreover, the FFT circuit 83 carries out FFT processing of the preamble signal $r0$ of an OFDM signal (i), and calculates the request discrimination signal $rf1(1)$, $rf1(2)$, and $rf1(3)$ for every frequency.

[0182] Next, only four sorts of amounts of phases ($0\text{degree}\theta^{**}$, $2\theta^{**}$ $3\theta^{**}$) carry out revolution processing of the request discrimination signal $rf1(1)$, and the phase revolution machine 1000 outputs these request discrimination signals $rf1(1 \ \theta)$, $rf1(1 \ 2\theta)$, and $rf1(1 \ 3\theta)$ by which revolution processing was carried out, and the request discrimination signal $rf1(1)$.

[0183] Furthermore, only four sorts of amounts of phases ($0 \ \text{degree}$, θ^{**} , $2\theta^{**}$, $3\theta^{**}$) carry out revolution processing of the request discrimination signal $rf1(2)$, and the phase revolution machine 1000 outputs these request discrimination signals $rf1(2 \ \theta)$, $rf1(2 \ 2\theta)$, and $rf1(2 \ 3\theta)$ by which revolution processing was carried out, and the request discrimination signal $rf1(2)$.

[0184] Moreover, only four sorts of amounts of phases ($0\text{degree}\theta^{**}$, $2\theta^{**}$ $3\theta^{**}$) carry out revolution processing of the request discrimination signal $rf1(3)$, and the phase revolution machine 1000 outputs these request discrimination signals $rf1(3 \ \theta)$, $rf1(3 \ 2\theta)$, and $rf1(3 \ 3\theta)$ by which revolution processing was carried out, and the request discrimination signal $rf1(3)$.

[0185] Here, request discrimination signal $rf1(1) - rf1(1 \ 3\theta)$, $rf1(2) - rf1(2 \ 3\theta)$, and $rf1(3) - rf1(3 \ 3\theta)$ are calculated as shown in a formula 34.

[0186]

[Equation 34]

$$BS = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \\ C_{41} & C_{42} & C_{43} \end{bmatrix} \begin{bmatrix} rf1(1) & 0 & 0 \\ 0 & rf1(2) & 0 \\ 0 & 0 & rf1(3) \end{bmatrix}$$

[0187] However, the amount of phases which shows C_{tf} in a formula 35, the number t indicates the amount of phases to be, and f are numbers which show a frequency. Moreover, they are $C_{11}=C_{12}=C_{13}$, $C_{21}=C_{22}=C_{23}$, and $C_{31}=C_{32}=C_{33}$ with a formula 35.

[0188]

[Equation 35] $C_{tf} = \exp \{-2\pi j - (j-1) - (t-1)/3\}$

Here, the output signal of the phase revolution machine 1000 is equivalent to what combined the output signal of the FFT circuit 84 and the output signal of the FFT circuit 83 which are shown in drawing 5. That is, the FFT circuit 84 generates a time delay shorter than the guard interval period TG to the preamble signal $r_0(i)$ with the phase revolution machine 1000, and plays a role equivalent to carrying out FFT processing of this generated time delay.

[0189] Next, correlator 1010 calculates the correlation value K of the request processing signal BS and discrimination signal $X(i)'$. In addition, the correlation value K is calculated by the matrix product $(BS \times X(i)')$ of the request processing signal BS and discrimination signal $X(i)'$.

[0190] Based on the correlation value K , as for a selection circuitry 1020, the request processing signal BS_{\max} with the largest correlation with discrimination signal $X(i)'$ among the request processing signals BS is searched for for every frequency.

[0191] For example, the vector notation of the correlation value K is carried out like a formula 36. The number t indicates the amount of phases to be in the correlation value k_{tf} , and f are numbers which show a frequency among a formula 36.

[0192]

[Equation 36]

$$K = \begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \\ K_{31} & K_{32} \\ K_{41} & K_{42} \end{bmatrix}$$

[0193] First, a selection circuitry 1020 adds the square value $(**k_{tf}**^2)$ of an absolute value for every amount of phases respectively, and searches for the matrix KG which shows in a formula 37 while it calculates each absolute value of the correlation value k_{tf} and calculates the square value $(**k_{tf}**^2)$ of each absolute value.

[0194]

[Equation 37]

$$KG = \begin{bmatrix} |K_{11}|^2 + |K_{12}|^2 \\ |K_{21}|^2 + |K_{22}|^2 \\ |K_{31}|^2 + |K_{32}|^2 \\ |K_{41}|^2 + |K_{42}|^2 \end{bmatrix}$$

[0195] Next, a selection circuitry 1020 searches for the request discrimination signal (henceforth the request discrimination signal MX) corresponding to the amount of phases of maximum for every frequency among Matrices BS while calculating maximum among Matrices KG .

[0196] Here, it is the request discrimination signal $rf_1(1)$. — $rf_1(2)$ — The vector notation of the matrix BS which shows $rf_1(3 \theta)$ is carried out like a formula 38.

[0197]

[Equation 38]

$$BS = \begin{bmatrix} rf_1(1) & rf_1(2) & rf_1(3) \\ rf_1(1 \theta) & rf_1(2 \theta) & rf_1(3 \theta) \\ rf_1(1 2\theta) & rf_1(2 2\theta) & rf_1(3 2\theta) \\ rf_1(1 3\theta) & rf_1(2 3\theta) & rf_1(3 3\theta) \end{bmatrix}$$

[0198] as the maximum of for example, the matrix KG — [— the time of $**k_{21}**^2 + **k_{22}**^2$ being chosen — the inside of a formula 38 — as the request discrimination signal MX for

every frequency (i) — [— rf1 (1 2theta) rf1 (2 2theta) and rf1(3 2theta)] are chosen.

Furthermore, as request discrimination signals other than the request discrimination signal MX for every frequency (i) are shown in a formula 39 among formulas 38, it considers as the request processing signal BA. However, the request processing signal BA of a formula 39 shows an example as which [rf1 (1 2theta) rf1 (2 2theta) and rf1(3 2theta)] were chosen as a request discrimination signal MX (i).

[0199]

[Equation 39]

$$BA = \begin{bmatrix} rf1(1) & rf1(2) & rf1(3) \\ rf1(1 \theta) & rf1(2 \theta) & rf1(3 \theta) \\ rf1(1 3\theta) & rf1(2 3\theta) & rf1(3 3\theta) \end{bmatrix}$$

[0200] In addition, hereafter, in order to give explanation simply, as shown in a formula 40, the vector notation of the request processing signal BA (i) is carried out, and as shown in a formula 41, the vector notation of the request discrimination signal MX (i) is carried out. The number t indicates the amount of phases to be in the correlation value batf, and f are numbers which show a frequency among a formula 40. In mxt, t is a number which shows the amount of phases among a formula 41.

[0201]

[Equation 40]

$$BA(i) = \begin{bmatrix} ba_{11}(i) & ba_{21}(i) & ba_{31}(i) \\ ba_{12}(i) & ba_{22}(i) & ba_{32}(i) \\ ba_{13}(i) & ba_{23}(i) & ba_{33}(i) \end{bmatrix}$$

[0202]

[Equation 41]

$$MX(i) = \begin{bmatrix} mx_1 & mx_2 & mx_3 \end{bmatrix}$$

[0203] In addition, hereafter, as shown in a formula 42, the vector notation of discrimination signal X (i)' is carried out. However, M of ftMf in a formula 42 shows the number of an antenna element with the natural number, and f shows a frequency.

[0204]

[Equation 42]

$$X(i)' = \begin{bmatrix} ft_{11}(i) & ft_{12}(i) & ft_{13}(i) \\ ft_{21}(i) & ft_{22}(i) & ft_{23}(i) \end{bmatrix}$$

[0205] Next, the matrix-of-correlation presumption machine 1031 combines discrimination signal X (i)' and the request processing signal BA, and it asks for the instant input matrices RXMXM1, RXMXM2, and RXMXM3 in each time of day in Matrix XM with a formula 44, a formula 45, and a formula 46 while it generates the matrix XM shown in a formula 43. Based on a formula 47, the instant input matrices RXMXM1, RXMXM2, and RXMXM3 are equalized, and the estimate RXMXM of a matrix of correlation is calculated.

[0206]

[Equation 43]

$$XM(i) = \begin{bmatrix} X'(i) \\ BA(i) \end{bmatrix} = \begin{bmatrix} ft_{11}(i) & ft_{12}(i) & ft_{13}(i) \\ ft_{21}(i) & ft_{22}(i) & ft_{23}(i) \\ ba_{11}(i) & ba_{21}(i) & ba_{31}(i) \\ ba_{12}(i) & ba_{22}(i) & ba_{32}(i) \\ ba_{13}(i) & ba_{23}(i) & ba_{33}(i) \end{bmatrix}$$

[0207]

[Equation 44] $RXMXM1 = XM(1)$ and $XM(1) H$ [0208]

[Equation 45] $RXMXM2 = XM(2)$ and $XM(2) H$ [0209]

[Equation 46] $RXMXM3 = XM(3)$ and $XM(3) H$ [0210]

[Equation 47]

$RXMXM = (RXMXM1 + RXMXM2 + RXMXM3) / 3$, next the inverse-matrix computing element 1032 calculate inverse-matrix $RXMXM^{-1}$ of the estimate $RXMXM$ of a matrix of correlation. Moreover, the correlation vector presumption machine 1033 searches for discrimination signal $X(i)'$ and the instant correlation vectors [in / as shown in a formula 48, a formula 49, and a formula 50 using the request discrimination signal MX and the request discrimination signal BA / each time of day] $rxmb1$, $rxmb2$, and $rxmb3$.

[0211] Next, based on a formula 51, the correlation vector presumption machine 1033 equalizes the instant correlation vectors $rxmb1$, $rxmb2$, and $rxmb3$ on a frequency, and calculates the correlation vector estimate $rxmb$.

[0212]

[Equation 48] $rxmb1 = XM(1)$ and $MX(1) H$ [0213]

[Equation 49] $rxmb2 = XM(2)$ and $MX(2) H$ [0214]

[Equation 50] $rxmb3 = XM(3)$ and $MX(3) H$ [0215]

[Equation 51] It outputs " $w1 * w2 *$ " to multipliers 201 and 202 among the multiplication results Z at it, respectively while matrix multiplication of the matrix multiplication machine 1034 is carried out to the $rxmb = (rxmb1 + rxmb2 + rxmb3) / 3$ last and it asks it for the multiplication result Z with the estimate $RXMXM$ of a matrix of correlation, and the correlation vector estimate $rxmb$, as shown in a formula 52. In addition, the inside of a formula 51, $-a1 - a2 - a3 - a4$ are the signal weight stated to the above-mentioned 3rd operation gestalt.

[0216]

[Formula 52]

It can $Z = [w1 * w2 * -a1 -a2 -a3 -a4] T$ Come, and are alike. More multipliers 201 and 202 It asks for a matrix product ($w1 * FT1(i)$) and a matrix product ($w2 * FT2(i)$), respectively, and by the adder (sigma) 300, a matrix product ($w1 * FT1(i)$) and ($w2 * FT2(i)$) are added for every frequency, and inner product signal $WHX(i)'$ is called for.

[0217] The antenna weight $w1$ and $w2$ are updated so that the component except the request processing signal BA and the request discrimination signal MX may be oppressed among inner product signal $WHX(i)'$ here. This prevents oppression with the request processing signal BA and the request discrimination signal MX without the need for oppression, and as substantially as the above-mentioned 1st and 2nd operation gestalt, since the signal component which originally has the need for oppression similarly can be oppressed, the Nur point can be formed in an effective target. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an SMI method can be held down.

[0218] For example, as shown in [alpha] drawing 22, directivity can be formed by antenna elements 11 and 12.

[0219] That is, delay-GI outside signals other than the request processing signals BA and MX are oppressed among inner product signal $WHX(i)'$, without oppressing the request discrimination signal MX . However, if a delay-GI outside signal and the request processing signal BA are received from the same, both a delay-GI outside signal and the request processing signal BA will be oppressed. Thus, among inner product signal $WHX(i)'$, although the request discrimination signal MX is not oppressed and is left behind, the request processing signal BA may be oppressed depending on a receive direction.

[0220] Furthermore, the component of the request discrimination signal MX is left behind at least among inner product signal $WHX(i)'$ by the antenna weight $w1$ and renewal of $w2$, and it is obtained. Here, since correlation with discrimination signal $X(i)'$ is the largest signal among the request processing signals BS like ****, a signal with big receiving level can acquire the request discrimination signal MX as a component of the request discrimination signal MX among discrimination signal $X(i)'$ by leaving behind the component of the request discrimination signal MX . Therefore, it can restore to the component of the request discrimination signal MX good.

[0221] In the above-mentioned 11th operation gestalt, the FFT circuits 801 and 802 are adopted and adaptive AREANTENA of an SMI method is constituted. In addition, the FFT circuits 801 and 802 Although explained per [which carries out FFT processing of the receiving OFDM signal x1 (i), and asks for the antenna weight w1 and w2 based on the signal on this frequency shaft by which FFT processing was carried out, respectively] example, you may make it be not only this but the following.

[0222] That is, without adopting the FFT circuits 801 and 802, adaptive AREANTENA of an SMI method is constituted, the receiving OFDM signal x1 (i) is replaced with the signal on the frequency shaft which carried out FFT processing, the receiving OFDM signal x1 on a time-axis (i) is adopted, and you may make it ask for the receiving OFDM signal x1(i) antenna weight w1 and w2 on a time-axis.

(The 11th operation gestalt) With the **** 11 operation gestalt, as shown in drawing 22 , low pass filters (LPF) 1040 and 1041 are added to the configuration which the above-mentioned 10th operation gestalt shows.

[0223] In drawing 22 , a low pass filter 1040 searches for the discrimination signal LF 1 of a narrow-band $\{=ft_1(1), ft_1(2)\}$ based on discrimination signal $ft_1(1) - ft_1$ from the FFT circuit 801 (3). With this, a low pass filter 1040 searches for the discrimination signal LF 2 of a narrow-band $\{=ft_2(1), ft_2(2)\}$ based on discrimination signal $ft_2(1) - ft_2$ from the FFT circuit 802 (3).

[0224] By this, a low pass filter 1040 will output the discrimination signal LF of the narrow-band shown in a formula 53. That is, a low pass filter 1040 outputs the discrimination signals LF1 and LF2 of a narrow-band by taking out only the component of a predetermined frequency band among discrimination signal $ft_1(1) - ft_1(3) ft_2(1) - ft_2(3)$.

[0225]

[Equation 53]

$$LF = \begin{bmatrix} LF_1 \\ LF_2 \end{bmatrix} = \begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \end{bmatrix}$$

[0226] Moreover, it connects between the FFT circuit 83 and the phase revolution machine 1000, and a low pass filter 1041 searches for the discrimination signal rLF of a narrow-band $\{=rf_1(1), rf_1(2)\}$ based on the request discrimination signal rf1 from the FFT circuit 83 (1), rf1 (2), and rf1 (3). That is, a low pass filter 1041 outputs the discrimination signal rf1 of a narrow-band (1), and rf1 (2) by taking out only the component of a predetermined frequency band among the request discrimination signal rf1 (1), rf1 (2), and rf1 (3).

[0227] Next, only four sorts of amounts of phases (0 degree, θ , 2θ , 3θ) carry out revolution processing of the request discrimination signal rf1 (1), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (1 θ), rf1 (1 2θ), and rf1 (1 3θ) by which revolution processing was carried out, and the request discrimination signal rf1 (1).

[0228] Furthermore, only four sorts of amounts of phases (0 degree, θ , 2θ , 3θ) carry out revolution processing of the request discrimination signal rf1 (2), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (2 θ), rf1 (2 2θ), and rf1 (2 3θ) by which revolution processing was carried out, and the request discrimination signal rf1 (2).

[0229] In addition, hereafter, request discrimination signal $rf_1(1) - rf_1(1 \ 3\theta)$ and $rf_1(2) - rf_1(2 \ 3\theta)$ are made into the request processing signal LBS, as shown in a formula 54.

[0230]

[Equation 54]

$$LBS = \begin{bmatrix} rf_1(1) & rf_1(2) \\ rf_1(1 \ \theta) & rf_1(2 \ \theta) \\ rf_1(1 \ 2\theta) & rf_1(2 \ 2\theta) \\ rf_1(1 \ 3\theta) & rf_1(2 \ 3\theta) \end{bmatrix}$$

[0231] next — **** — 11 — operation — a gestalt — correlator — 1010 — the above — the — ten — operation — a gestalt — having stated — a request — processing — a signal — BS — replacing — a request — processing — a signal — LBS — discrimination — a signal — X — (— i —) — ' — replacing — a narrow-band — discrimination — a signal — rLF — correlation — a value — K — ' — asking . moreover — a selection circuitry — 1020 — the above — the — ten — operation — a gestalt — substantial — the same — correlation — a value — K — ' — being based — a request — processing — a signal — LBS — inside — a narrow-band — discrimination — a signal — rLF — correlation — most — being large — a frequency — every — a request — discrimination — a signal — MX — ' — asking . Furthermore, it asks for request processing signal BA' other than request processing signal MX' among the request processing signals LBS.

[0232] Next, in a computing element 1030, while it replaces with discrimination signal X (i)', and the discrimination signal rLF of a narrow-band is inputted, replacing with the request processing signal MX and inputting request processing signal MX', it replaces with the request processing signal BA, and request processing signal BA' is inputted.

[0233] Then, the matrix-of-correlation presumption machine 1031 calculates inverse-matrix $RXMXM^{-1}$ of the estimate $RXMXM$ of a matrix of correlation while calculating [gestalt / above-mentioned / 10th operation] the estimate $RXMXM$ of a matrix of correlation substantially similarly based on the discrimination signal rLF of a narrow-band, and request processing signal MX' with the correlation vector presumption machine 1033 and the inverse-matrix computing element 1032.

[0234] Moreover, the correlation vector estimate rxmb is calculated using the discrimination signal rLF of a narrow-band, request discrimination signal MX', and request discrimination signal BA' as substantially [the correlation vector presumption machine 1033] as the above-mentioned 10th operation gestalt similarly. Furthermore, with the matrix multiplication vessel 1034, matrix multiplication of the estimate $RXMXM$ of a matrix of correlation and the correlation vector estimate rxmb is carried out, antenna weight w1 w2 are calculated, and it is outputted to multipliers 201 and 202, respectively.

[0235] Since the component except the request processing signal BA and the request discrimination signal MX is oppressed among inner product signal WHX (i)' by the above, the same effectiveness is substantially acquired with the above-mentioned 10th operation gestalt. Furthermore, since the component of request discrimination signal MX' is left behind at least among inner product signal WHX (i)' and it is obtained, it can restore to the component of the request discrimination signal MX good substantially similarly with the above-mentioned 10th operation gestalt.

[0236] Moreover, while replacing with the request processing signal BS and adopting the request processing signal LBS in the operation of the correlation value of correlator 1010, it replaces with discrimination signal X (i)', and the discrimination signal rLF of a narrow-band is adopted. Here, like ****, the request processing signal LBS has a narrow frequency domain compared with the request processing signal BS, and the discrimination signal rLF of a narrow-band has a frequency domain narrow [the signal] like **** compared with discrimination signal X (i)'. For this reason, the amount of operations of the correlation value of correlator 1010 can be reduced compared with the above-mentioned 10th operation gestalt.

[0237] Furthermore, since correlation value K' of correlator 1010, the request processing signal LBS, and the discrimination signal rLF of a narrow-band are adopted when a selection circuitry 1020 asks for request processing signal MX'BA', the amount of operations of a selection circuitry 1020 can be reduced compared with the above-mentioned 10th operation gestalt.

[0238] Moreover, when a computing element 1030 calculates antenna weight w1 w2, while replacing with discrimination signal X (i)' and adopting the discrimination signal rLF of a narrow-band, it replaces with the request processing signal MX, and request processing signal MX' is adopted. For this reason, the amount of operations of a computing element 1030 can be reduced compared with the above-mentioned 10th operation gestalt.

(The 12th operation gestalt) With a **** 12 operation gestalt, the low pass filters (LPF) 1040 and 1041 stated with the above-mentioned 11th operation gestalt are adopted, and it explains

per [which constitutes the adaptive array antenna of PI method] example. The configuration in this case is shown in drawing 23 .

[0239] The adaptive array antenna of PI method in a **** 12 operation gestalt consists of antenna elements 11 and 12, a generator 60, the FFT circuits 83, 801, and 802, multipliers 201 and 202, an adder (sigma) 300, a phase revolution machine 1000, low pass filters (LPF) 1040 and 1041, and computing-element 1030A. Computing-element 1030A has matrix-of-correlation presumption machine 1031A, inverse-matrix computing-element 1032A, and matrix multiplication machine 1034A. In addition, in drawing 23 , the same sign in drawing 1 , drawing 2 , and drawing 22 shows the same object.

[0240] First, like the above-mentioned 11th operation gestalt, while a low pass filter 1040 searches for the discrimination signal LF 1 of a narrow-band $\{=ft_1(1), ft_1(2)\}$ based on discrimination signal $ft_1(1) - ft_1$ from the FFT circuit 801 (3) Based on discrimination signal $ft_2(1) - ft_2$ from the FFT circuit 802 (3), the discrimination signal LF 2 of a narrow-band $\{=ft_2(1), ft_2(2)\}$ is searched for.

[0241] Next, the phase revolution machine 1000 searches for the request processing signal LBS shown in a formula 53 like the above-mentioned 11th operation gestalt based on the discrimination signal rLF of the narrow-band from a low pass filter 1041 $\{=rf_1(1), rf_1(2)\}$.

[0242] Next, it computing-element 1030A Sets and matrix-of-correlation presumption machine 1031A combines the discrimination signals LF1 and LF2 and the request processing signal LBS of a narrow-band, and while generating the matrix FB shown in a formula 55, the above-mentioned 10th operation gestalt and the substantial estimate [in / similarly / Matrix FB] RFBFB of a matrix of correlation are calculated.

[0243]

[Equation 55]

$$FB = \begin{bmatrix} LF_1 \\ LF_2 \\ LBS \end{bmatrix} = \begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \\ rf_1(1) & rf_1(2) \\ rf_1(1 \ \theta) & rf_1(2 \ \theta) \\ rf_1(1 \ 2\theta) & rf_1(2 \ 2\theta) \\ rf_1(1 \ 3\theta) & rf_1(2 \ 3\theta) \end{bmatrix}$$

[0244] Next, inverse-matrix computing-element 1032A calculates inverse-matrix RFBFB-1 of the estimate RFBFB of a matrix of correlation. Furthermore, matrix multiplication machine 1034A outputs antenna weight $w_1 w_2$ to multipliers 201 and 202 among multiplication result Z' , respectively while asking for multiplication result Z' using the formula showing in a formula 56. In addition, the inside of a formula 55, $-a_1 -a_2 -a_3 -a_4$ is the signal weight AH stated to the above-mentioned 9th operation gestalt.

[0245] Here, antenna weight $w_1 w_2$ are updated so that power of the component except the request processing signal LBS may be made into min among inner product signal [of an adder circuit 300] $WHX(i)'$.

[0246]

[Equation 56]

$$\begin{aligned} Z' &= [1 \ 0 \ 0 \ 0]^T \times R_{FBFB}^{-1} \\ &= [w_1^* \ w_2^* \ -a_1 \ -a_2 \ -a_3 \ -a_4]^T \end{aligned}$$

Furthermore, when computing-element 1030A calculates antenna weight $w_1 w_2$, while the discrimination signal rLF of a narrow-band is adopted, the request processing signal LBS is adopted. The frequency band of the discrimination signal rLF of a narrow-band is narrow here compared with the frequency band of discrimination signal $X(i)'$ stated with the above-mentioned 10th operation gestalt, and the frequency band of the request processing signal LBS is narrow compared with the frequency band of the request processing signal BS stated with the above-mentioned 10th operation gestalt. Therefore, computing-element 1030A can reduce the

amount of operations compared with the time of using discrimination signal X (i)' and the request processing signal BS.

[0247] In addition, if it is two or more pieces as the number of antenna elements in operation of this invention, it is good without limit.

[0248] Furthermore, in carrying out frequency discrimination of the various signals, the example which adopted FFT processing was explained with each above-mentioned operation gestalt, but various kinds of frequency discrimination processings, such as not only this but DFT processing, may be adopted.

[Translation done.]

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TECHNICAL FIELD

[Field of the Invention] This invention relates to an adaptive array antenna.

[Translation done.]

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 PRIOR ART

[Description of the Prior Art] In recent years, the various proposals of the adaptive array antenna of the MMSE method which receives the input signal of a rectangular cross multi-carrier method are made. First, the outline of the signal (the signal of a rectangular cross multi-carrier method is hereafter called OFDM signal) of a rectangular cross multi-carrier method is explained with reference to drawing 25 and drawing 26.

[0003] As shown in drawing 25, the OFDM signal consists of a data signal and a preamble signal before this data signal. A preamble signal is a signal which arranged two or more pilot symbols (known signal) on the frequency shaft. A data signal consists of two or more OFDM symbols by which time multiplied was carried out, and an OFDM symbol consists of a guard interval GI before an effective symbol and this effective symbol.

[0004] the guard interval GI — an effective symbol — the predetermined period part on [inner] the backside is copied. Therefore, if the time delay of the delay signal over a desired OFDM signal is shorter than the period TG of the guard interval GI when the sum of a desired OFDM signal and a desired delay signal is received as an input signal as shown in drawing 26, data (for example, QPSK symbol) can restore an input signal by FFT processing (frequency discrimination processing).

[0005] Next, the adaptive array antenna of an MMSE (Minimum Mean Square Error) method is explained with reference to drawing 23. Drawing 27 shows the outline configuration of the adaptive array antenna of an MMSE method. The adaptive array antenna of an MMSE method is an antenna element 11. — They are 1M and a multiplier 21. — It consists of 2M, the adder (sigma) 30, an MMSE computing element 40, an adder 50, and a generator 60. In addition, M is the natural number.

[0006] Antenna element 11 — 1M receive an OFDM signal through an electric wave, and output the receiving OFDM signal X (i), respectively. Here, the receiving OFDM signal X (i) can be expressed with a formula 1. T shows transposition. i shows time of day.

[0007]

[Equation 1]

$X(i) = [x_1(i) \ x_2(i) \ \dots \ x_M(i)]^T$ — this sake — antenna element 11 — 1M — respectively — the receiving OFDM signal $x_1(i)$, $x_2(i)$, and $x_M(i)$ is outputted. Moreover, the MMSE computing elements 50 are multipliers 21 and 22. — Multiplication is carried out to each of 2M at the antenna weight W_H .

[0008] Here, the antenna weight W_H can be expressed with a formula 2. H is complex-conjugate transposition.

[0009]

[Equation 2] A multiplier 20 carries out the multiplication of the receiving OFDM signal $x_1(i)$ to antenna weight w_1^* , and outputs a multiplication signal ($w_1^*x_1(i)$), and a multiplier 21 carries out the multiplication of the receiving OFDM signal $x_2(i)$ to antenna weight w_2^* , and outputs a multiplication signal ($w_2^*x_2(i)$) to a $W = [w_1 \ w_2 \ \dots \ w_M]^T$ concrete target. Multiplier 2M carry out the multiplication of the receiving OFDM signal $x_M(i)$ to antenna weight w_M^* , and output a multiplication signal ($w_M^*x_M(i)$).

[0010] An adder (sigma) 30 is a multiplication signal ($w_1^*x_1(i)$) and a multiplication signal ($w_2^*x_2$

(i)). — The inner product signal $WHX(i)$ which shows the inner product of the antenna weight W and the receiving OFDM signal $X(i)$ is searched for by adding a multiplication signal ($wM \times xM(i)$). a generator 60 memorizes a reference sign $r0(i)$ beforehand, and outputs this reference sign $r0(i)$ to an adder 50, and an adder 50 asks for error [of a reference sign $r0(i)$ and the inner product signal $WHX(i)$] $e(i)$ — $\{ - e(i) = r0(i) - WHX(i) - \}$. The MMSE computing element 40 updates the antenna weight W so that this error $e(i)$ may be made small by considering the receiving OFDM signal $X(i)$ and error $e(i)$ as an input, and it is multipliers 21 and 22 about that antenna weight W . — It outputs to 2M.

[0011] Here, the delay signal except a request known signal etc. can be oppressed among the receiving OFDM signals $X(i)$ by adopting a request known signal (for example, preamble signal on a time-axis) as a reference sign $r0(i)$. Incidentally, in the adaptive array antenna of an MMSE method, the number of the known signals (null point) which can be oppressed is prescribed by the number of antenna elements, and it is (the number of antenna elements). — It is "1." Hereafter, the number of the known signals (null point) which can be oppressed is called degree of freedom.

[Translation done.]

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] By the way, in the adaptive array antenna of an MMSE method, although the time delay of the delay signal over a request known signal can restore data (the data 1 in drawing 26 - data 4) from an input signal if it is shorter than the period TG of the guard interval GI when the sum of a request known signal and its delay signal is received as an input signal like ****, the delay signal (henceforth the delay signal in GI) concerned will be oppressed.

[0013] It becomes impossible thus, to compound two or more signals and to raise the receiving engine performance by there being no need of oppressing and oppressing the delay signal in GI which can be restored and compounded.

[0014] moreover, null [in / in order to oppress the delay signal in GI / an adaptive array antenna] -- the delay signal delayed for the delay signal in GI since a point would be formed -- like -- original -- null -- the signal which should form a point -- null -- there is a problem of it becoming impossible to form a point. That is, the degree of freedom of an adaptive array antenna will be consumed vainly.

[0015] This invention aims at offering the adaptive array antenna which held down useless consumption of a degree of freedom in view of the above.

[Translation done.]

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MEANS

[Means for Solving the Problem] In order to attain the above-mentioned object, this invention in invention according to claim 1 The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by two or more antenna elements (11 — 1M) and two or more antenna elements (21 — 2M), An addition means by which antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A reference calculation means to ask for a reference sign from the 1st known signal and the 2nd known signal (51-53, 51A, 53A), It is characterized by having an updating means (40A, 41) to update antenna weight according to the input signal, reference sign, and addition signal which were received by two or more antenna elements.

[0017] Here, a reference sign is computed from the 1st and 2nd known signals, and an updating means updates antenna weight according to a reference sign and the above-mentioned input signal concerned, the 2nd known signal, and an addition signal. For this reason, an updating means can oppress the component except the 1st and 2nd known signals by renewal of antenna weight among the input signals received by two or more antenna elements. Therefore, since oppression of the 2nd known signal is prevented and a signal component with the need for oppression can originally be oppressed when oppression of the 2nd known signal is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the degree of freedom of an adaptive array antenna is held down.

[0018] Moreover, since the component except the 2nd known signal is oppressed among [1st] input signals, the composite signal of the 1st and 2nd known signals can be acquired among input signals. Here, like invention according to claim 2, the 2nd known signal can acquire a good recovery signal, when it is the delay signal which carried out predetermined period delay to said 1st known signal and gets over using the composite signal of the 1st and 2nd known signals compared with the case where it restores only to the 1st known signal.

[0019] Furthermore, you may make it have a delay means (80) to carry out predetermined period delay of the 1st known signal, and to search for the 2nd known signal like invention according to claim 3. Moreover, the 2nd known signal is not prepared beforehand but you may make it search for the 2nd known signal according to an input signal.

[0020] Like invention according to claim 4, namely, two or more antenna elements The signal which has the component of the 1st known signal and the component of the 2nd known signal is received as an input signal, respectively. Based on the input signal received by two or more antenna elements, it has a time delay calculation means (100) to find the time delay of the component of the 2nd [to the component of the 1st known signal] known signal, and only a time delay delays a request known signal and you may make it a delay means search for the 2nd known signal.

[0021] Furthermore, a delay signal generation means by which only time amount which is different to the 1st known signal, respectively generates two or more delay signals for ***** like invention according to claim 5 (90), You may make it have the correlating detector (131a-134c) which performs correlation detection of each delay signal of a delay signal generation means, and said input signal, and a selection means (135a-136) to choose any of two or more delay signals they are as 2nd known signal based on the correlation detection of a correlating

detector.

[0022] Like invention according to claim 6, specifically a reference-sign calculation means The 1st known signal is added to the 2nd known signal with which the multiplication of the signal weight was carried out to the 2nd known signal, and the multiplication of this signal weight was carried out, and it asks for a reference sign. An updating means You may make it update signal weight according to the input signal and the 2nd known signal which were received by two or more antenna elements, a reference sign, and an addition signal.

[0023] An oppression means to add a return signal by invention according to claim 7 here in order to oppress the component of the known signal of [2nd] the addition signals of an addition means (129 130), It is characterized by having an addition signal delay means (121-124) only for a predetermined period to delay an addition signal and to generate a delay addition signal, and a multiplication means (125-128) to carry out the multiplication of said signal weight to a delay addition signal, and to ask for said return signal. Thereby, an oppression means oppresses the component of the 2nd known signal among addition signals, and can output only the component of the 1st known signal.

[0024] Two or more antenna elements [invention / according to claim 8] (11 — 1M), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801-80M), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201-20M), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A request frequency judgment means to search for the request discrimination signal with which frequency discrimination of the request OFDM signal was carried out (84), A delay means to search for the delayed discrimination signal delayed to the request discrimination signal (90 83), A reference addition means to add a request discrimination signal to the delayed discrimination signal with which the multiplication of the signal weight was carried out to the delayed discrimination signal, and the multiplication of this signal weight was carried out, and to ask for a reference sign (510, 520, 530), According to each of said discrimination signal and said delayed discrimination signal, said addition signal is brought close to said reference sign. It is characterized by having an updating means (40B) to update said antenna weight and said signal weight so that the component except the both sides of said request discrimination signal and a delayed discrimination signal may be oppressed among said each discrimination signal.

[0025] Thus, an updating means updates antenna weight and signal weight so that the component except the both sides of a request discrimination signal and a delayed discrimination signal may be oppressed among each discrimination signal. For this reason, since oppression of a delayed discrimination signal is prevented and a signal component with the need for oppression can originally be oppressed when oppression of a delayed discrimination signal is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the degree of freedom of an adaptive array antenna is held down.

[0026] Moreover, since an updating means updates antenna weight and signal weight so that the component except the both sides of a request discrimination signal and a delayed discrimination signal may be oppressed among each discrimination signal like ****, it can obtain the both sides of a request discrimination signal and a delayed discrimination signal among each discrimination signal. If it gets over using the both sides of such a request discrimination signal and a delayed discrimination signal, a good recovery signal will be acquired compared with the case where it gets over only by the request discrimination signal.

[0027] Two or more antenna elements [invention / according to claim 9] (11-14), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by said two or more antenna elements, respectively, and to search for a discrimination signal (801-804), The antenna multiplication means which carries out the multiplication of the antenna weight to said each discrimination signal by which frequency discrimination was carried out (201-204), An addition means by which said antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal

(300), A delay means to search for the delay OFDM signal which carried out predetermined period delay to the request OFDM signal (80A), A request frequency judgment means by which the both sides of said request OFDM signal and said delay OFDM signal search for the request discrimination signal by which frequency discrimination was carried out (834), A reference addition means to carry out the multiplication of the signal weight to said request discrimination signal, and to ask for a reference sign (530A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (510A), It is characterized by having an updating means (42) to update said antenna weight and said signal weight so that power of the component except said request discrimination signal may be made small among said addition reference signs.

[0028] Thus, since an updating means updates antenna weight and signal weight so that power of the component except the component of request discrimination ***** may be made small among addition reference signs, it can make small power of the component except the component of a request discrimination signal among addition reference signs. Therefore, while oppression of the signal with which oppression of a request discrimination signal is prevented, namely, frequency discrimination of the request OFDM signal was carried out is prevented, oppression of the signal with which frequency discrimination of the delay OFDM signal was carried out is prevented.

[0029] For this reason, since a signal component with the need for oppression can originally be oppressed when oppression of the signal with which frequency discrimination of the delay OFDM signal was carried out is unnecessary, the Nur point can be formed in an effective target. For this reason, useless consumption of the degree of freedom of an adaptive array antenna is held down.

[0030] Moreover, you may make it have a generation means (60) to generate the preamble signal with which the known signal was arranged on the frequency shaft as said request OFDM signal like invention according to claim 10. Furthermore, like invention according to claim 11, a received frequency discrimination means may carry out the thump rig of the receiving OFDM signal, each sampling signal may be acquired, said discrimination signal may be searched for according to each sampling signal, and you may make it a time delay be the predetermined multiple of the period of a sampling.

[0031] Furthermore, in invention according to claim 12, a delay means is characterized by outputting one delayed discrimination signal and said delayed discrimination signal of the request number. Thereby, like invention according to claim 1, an updating means can update said each antenna weight and signal weight so that the component except said request discrimination signal and the delayed discrimination signal of the request number may be oppressed among said each discrimination signal.

[0032] Furthermore, in invention according to claim 13, the request number of a delayed discrimination signal is characterized by being the maximum number decided by the guard interval period of the data signal of a request OFDM signal, and the period of a sampling. Thereby, further, since oppression of many delayed discrimination signals can be prevented, useless consumption of the degree of freedom of an adaptive array antenna can be held down effectively. In addition, the maximum number of a delayed discrimination signal is $\{(\text{period of a guard interval period} / \text{sampling}) - 1\}$.

[0033] In invention according to claim 14, a reference-sign calculation means A means to carry out the multiplication of the signal weight to said 1st and 2nd known signals, and to ask for said reference sign (53A), It has a means (51A) to add said reference sign and said addition signal, and to ask for an addition reference sign. Said updating means (41) It is characterized by updating said antenna weight and said signal weight so that power of the component except said 1st and 2nd known signals may be made small among said addition reference signs.

[0034] Thus, since an updating means (41) updates antenna weight and signal weight so that power of the component except the 1st and 2nd known signals may be made small among addition reference signs, it can make small power of the component except the 1st and 2nd known signals among addition reference signs. For this reason, control of the 1st and 2nd known signals can be prevented, and since a signal component with the need for oppression can

originally be oppressed when control of the 2nd known signal is unnecessary, the Nur point can be formed in an effective target.

[0035] Two or more antenna elements [invention / according to claim 15] (11-14), The antenna multiplication means which carries out the multiplication of each antenna weight to the input signal received by said two or more antenna elements (21—24), An addition means by which said antenna weight adds each input signal by which multiplication was carried out, and outputs an addition signal (30), A received signalling frequency output means to output the received signalling frequency which shows the component of a narrow frequency band compared with the frequency band of these input signals among the input signals received by said two or more antenna elements, respectively (420-423), A known signalling frequency output means to output the known signalling frequency which shows the component of said narrow frequency band among known signals (424), A delay means to search for the delay signalling frequency which carried out predetermined period delay to said known signalling frequency (80A), A reference-sign calculation means to carry out the multiplication of the signal weight to said delay signalling frequency and said known signalling frequency, and to ask for a reference sign (53A), An addition reference-sign calculation means to add said reference sign and said addition signal, and to ask for an addition reference sign (51A), It is characterized by having an updating means (41) to update said antenna weight and said signal weight so that power of the component except said delay signalling frequency and said known signalling frequency may be made small among said addition reference signs.

[0036] Thus, since an updating means updates antenna weight and signal weight so that power of the component except delay signalling frequency and known signalling frequency may be made small among addition reference signs, it can make small power of the component except delay signalling frequency and known signalling frequency among addition reference signs. For this reason, control of delay signalling frequency and known signalling frequency can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of delay signalling frequency is unnecessary, the Nur point can be formed in an effective target.

[0037] Here, the count of updating of antenna weight and signal weight is decided by the frequency band of an input signal, and since it replaces with an input signal in renewal of antenna weight and signal weight and the known signalling frequency of a narrow frequency band is used for it like **** compared with the frequency band of an input signal, it can reduce the count of updating of antenna weight and signal weight.

[0038] Moreover, two or more antenna elements [invention / according to claim 16] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A known frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A phase revolution means only for each amount of phases to carry out a phase revolution to a known discrimination signal, and to search for the phase revolution known discrimination signal corresponding to each amount of phases (1000), A correlation means to take correlation with the phase revolution known discrimination signal corresponding to each amount of phases, and each discrimination signal, and to calculate the correlation value corresponding to each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to each amount of phases the phase revolution known discrimination signal corresponding to each amount of phases — with a selection means (1020) to choose the response phase revolution known discrimination signal corresponding to a maximum correlation value inside While making small the component except the phase revolution known discrimination signal corresponding to each amount of phases among addition signals, it is characterized by having an updating means (1034) to update antenna weight so that it may leave a response phase revolution known

discrimination signal at least among addition signals.

[0039] Thus, an updating means updates the antenna weight which makes small the component except the phase revolution known discrimination signal corresponding to each amount of phases among addition signals. Therefore, the component except the phase revolution known discrimination signal corresponding to each amount of phases can be made small among addition signals. For this reason, control of the phase revolution known discrimination signal corresponding to each amount of phases can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of the phase revolution known discrimination signal corresponding to each amount of phases is unnecessary, the Nur point can be formed in an effective target.

[0040] Furthermore, an updating means updates antenna weight so that it may leave the response phase revolution known discrimination signal corresponding to a maximum correlation value at least among addition signals. Therefore, it can leave the response phase revolution known discrimination signal corresponding to a maximum correlation value at least among addition signals.

[0041] Here, since a response phase revolution known discrimination signal is equivalent to the phase revolution known discrimination signal of a maximum-electric-power value among the phase revolution known discrimination signals corresponding to each amount of phases, it can acquire the big revolution known discrimination signal of a received-power value by leaving a response phase revolution known discrimination signal.

[0042] Two or more antenna elements [invention / according to claim 17] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among each discrimination signal compared with a discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among known discrimination signals compared with a known discrimination signal (1041), Only the amount of phases which is different to a narrow-band known discrimination signal, respectively carries out a phase revolution. A phase revolution means to search for the signal according to phase rotary valve of the narrow-band corresponding to each amount of phases (1000), A correlation means to take correlation with the signal according to phase rotary valve of the narrow-band corresponding to each amount of phases, and each discrimination signal, and to calculate the correlation value corresponding to each amount of phases (1010), While choosing a maximum correlation value among the correlation values corresponding to each amount of phases A selection means to choose the signal according to phase rotary valve of the narrow-band corresponding to a maximum correlation value among the signals according to phase rotary valve of each narrow-band (1020), While making small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals, it is characterized by having an updating means (1033) to update so that it may leave at least the signal according to phase rotary valve of the narrow-band which corresponds among addition signals.

[0043] Thus, since an updating means updates the antenna weight which makes small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals, it can make small the component except the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases among addition signals. For this reason, control of the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases can be prevented, and since a signal component with the need for oppression can

originally be oppressed when control of the phase revolution known discrimination signal of the narrow-band corresponding to each amount of phases is unnecessary, the Nur point can be formed in an effective target.

[0044] Furthermore, an updating means updates antenna weight so that it may leave the phase revolution known discrimination signal of the narrow-band corresponding to a maximum correlation value at least among addition signals. Therefore, it can leave the phase revolution known discrimination signal of the narrow-band corresponding to a maximum correlation value at least among addition signals.

[0045] Here, since said corresponding phase revolution known discrimination signal of a narrow-band is equivalent to the phase revolution known discrimination signal of a maximum-electric-power value among the phase revolution known discrimination signals corresponding to each amount of phases, it can acquire the big revolution known discrimination signal of a received-power value by leaving said corresponding phase revolution known discrimination signal of a narrow-band.

[0046] Here, since the signal according to phase rotary valve of a narrow-band is used when an updating means updates antenna weight, the amount of operations for updating can be reduced compared with invention according to claim 16.

[0047] Two or more antenna elements [invention / according to claim 18] (11 12), A received frequency discrimination means to carry out frequency discrimination of the receiving OFDM signal received by two or more antenna elements, respectively, and to search for a discrimination signal (801 802), The antenna multiplication means which carries out the multiplication of the antenna weight to each discrimination signal by which frequency discrimination was carried out (201 202), An addition means by which antenna weight adds each discrimination signal by which multiplication was carried out, and outputs an addition signal (300), A narrow-band output means to output the narrow-band discrimination signal of a narrow frequency band among each discrimination signal compared with a discrimination signal, respectively (1040), A request frequency judgment means to carry out frequency discrimination of the known OFDM signal, and to search for a known discrimination signal (83), A known narrow-band output means to output the narrow-band known discrimination signal of a narrow frequency band among known discrimination signals compared with a known discrimination signal (1041), The phase revolution means (1000) which carries out the phase revolution of the narrow-band known discrimination signal, and the inside of an addition signal, It is characterized by having an updating means (1030A) to update antenna weight so that power of the component except a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out may be made small.

[0048] Thus, since antenna weight is updated so that power of the component except the narrow-band known discrimination signal by which the phase revolution was carried out with the narrow-band known discrimination signal among addition signals may be made small, power of the component except a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out can be made small among addition signals. For this reason, control of a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out can be prevented, and since a signal component with the need for oppression can originally be oppressed when control of a narrow-band known discrimination signal and said narrow-band known discrimination signal by which the phase revolution was carried out is unnecessary, the Nur point can be formed in an effective target.

[0049] Here, since said narrow-band known discrimination signal by which the phase revolution was carried out and signal according to phase rotary valve of a narrow-band are used when an updating means computes antenna weight, the amount of operations for updating can be reduced.

[0050] Incidentally, the sign in the parenthesis of each above-mentioned means is an example which shows response relation with the concrete means of a publication to the operation gestalt mentioned later.

[0051]

[Embodiment of the Invention] (The 1st operation gestalt) The adaptive array antenna of the MMSE method which starts the 1st operation gestalt of this invention at drawing 1 is shown. In a **** 1 operation gestalt, the adaptive array antenna of an MMSE method shows the example which receives an OFDM signal. Drawing 1 is a block diagram about the outline configuration of the adaptive array antenna of an MMSE method. The adaptive array antenna of an MMSE method is an antenna element 11, as shown in drawing 1. — They are 1M (M is the natural number) and a multiplier 21. — It consists of 2M, an adder (sigma) 30, MMSE computing-element 40A, adders 51 and 52, a multiplier 53, and generators 60 and 70. In drawing 1, the same sign as the sign in drawing 18 shows the same object or a substantial same object.

[0052] A generator 60 generates the preamble signal r_0 (i) of an OFDM signal (i) as a request known signal, and this preamble signal r_0 (i) is a signal with which two or more pilot symbols (known signal) were arranged on the frequency shaft.

[0053] A generator 70 generates the delay signal of U (U is the natural number) individual to the preamble signal r_0 (i) as other known signals, and U delay signals have a different time delay to a preamble signal, respectively. However, each time delay of U delay signals over a preamble signal is short compared with the period TG of the guard interval GI of an OFDM symbol, and is hereafter set to delay signal R (i) which shows U delay signals in a formula 3.

[0054]

[Equation 3]

$R(i) = [-r_1(i) \ r_2(i) \ \dots \ r_U(i)]$ — < — SUP>T, next a multiplier 53 output the multiplication signal {AHR (i)} which carries out the multiplication of the signal weight AH expressed to a formula 4 to delay signal R (i), and is shown in a formula 5.

[0055]

[Equation 4] $A = [a_1 \ a_2 \ \dots \ a_U]^T$ [0056]

[Equation 5] $AHR(i) = a_1 * r_1(i) + a_2 * r_2(i) + \dots + a_U * r_U(i)$

Next, an adder 52 adds the preamble signal r_0 (i) and the multiplication signal AHR (i), and outputs an addition signal ($r_0(i) + AHR(i)$). Here, an addition signal ($r_0(i) + AHR(i)$) turns into a composite signal (reference sign) of the preamble signal r_0 (i) and delay signal R (i). And an adder 51 asks for error [of an addition signal ($r_0(i) + AHR(i)$) and the inner product signal WHX of an adder 30 (i)] e (i). Here, error e (i) can be expressed to a formula 6.

[0057]

[Equation 6] To $e(i) = r_0(i) + AHR(i) - WHX$, next MMSE computing-element 40A The receiving OFDM signal X (i), delay signal R (i), and error e (i) are inputted. MMSE computing-element 40A for example, SMI (Sample Matrix Inversion) of an MMSE method, while updating the antenna weight W and outputting to a multiplier 21 and 22 — 2M so that error e (i) may be made small based on law The signal weight A is updated and it outputs to a multiplier 53 so that error e (i) may be made small based on the SMI method of an MMSE method.

[0058] Thereby, as an inner product signal WHX of an adder 30, the component except preamble signal r_0 (i), (request known signal), and delay signal R (i) (other known signals) becomes a repressed signal among the receiving OFDM signals X (i).

[0059] Here, the signal weight A is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of delay signal R (i) and a (the 2nd known signal) on the basis of the preamble signal r_0 (i) and (the 1st known signal).

[0060] Hereafter, the description of a **** 1 operation gestalt is described. First, the time delay of delay signal R (i) to the preamble signal r_0 can restore data (for example, QPSK data symbol) for the inner product signal WHX of an adder 30 by FFT processing (frequency discrimination), without oppressing delay signal R (i) among the receiving OFDM signals X (i) like ****, since it is short compared with the period TG of the guard interval GI.

[0061] That is, oppression of delay signal R (i) is unnecessary among the receiving OFDM signals X (i). So, with a **** 1 operation gestalt, a repressed signal is acquired for the component except the preamble signal r_0 (i) and the delay signal AHR (i) among the receiving OFDM signals X (i) as an inner product signal WHX of an adder 30 like ****.

[0062] For this reason, since oppression of delay signal R (i) is prevented and a signal component with the need for oppression can originally be oppressed, the Nur point can be

formed in an effective target. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an MMSE method can be held down.

[0063] Moreover, since the addition signal ($r_0(i)+AHR(i)$) of the preamble signal $r_0(i)$ and delay signal $R(i)$ is acquired, if it restores to this addition signal as an inner product signal WHX of an adder 30, a good recovery signal will be acquired compared with the case where it restores to the preamble signal $r_0(i)$.

[0064] Here, the result of a simulation is shown in drawing 2. An axis of abscissa is the receiving include angle [deg] of the received electric wave on the basis of the adaptive array antenna of an MMSE method among drawing 2, and an axis of ordinate is an oppression ratio (dB). The chain line shows the result of the simulation which used the adaptive array antenna of the conventional MMSE method. A continuous line shows the result of the simulation which used the adaptive array antenna of the MMSE method of a **** 1 operation gestalt.

[0065] Although the delay signal in GI is oppressed in the adaptive array antenna of the conventional MMSE method so that drawing 2 may show, oppression of the delay signal in GI is prevented in the adaptive array antenna of the MMSE method of a **** 1 operation gestalt. However, the delay signal in GI is a delay signal which has a short time delay compared with Period (guard interval GI) TG to a request signal (preamble signal r_0).

[0066] Below, the SMI algorithm of the MMSE method of MMSE computing-element 40A in a **** 1 operation gestalt is described. First, error $e(i)$ shown in a formula 6 can be transformed, and error $e(i)$ can be expressed like a formula 7.

[0067]

[Equation 7]

$$\begin{aligned} e(i) &= r_0(i) + R(i) A^H - W^H X \\ &= r_0(i) - \{W^H X - R(i) A^H\} \\ &= r_0(i) - Y^H Z(i) \end{aligned}$$

Y is the antenna weight W and weight including the both sides of the signal weight A here, as shown in a formula 8, and $Z(i)$ is a signal including the both sides of the receiving OFDM signal $X(i)$ and delay signal $R(i)$, as expressed to a formula 9.

[0068]

[Equation 8] $Y = [w_1 \ w_2 \ w_3 \ \dots \ w_M - a_1 - a_2 - a_3 \ \dots - a_U]^T$ [0069]

[Equation 9] $Z = \begin{bmatrix} x_1 & \dots & x_M - r_1 & \dots & r_U \\ x_2 & \dots & r_1 & \dots & r_U \\ \vdots & & \vdots & & \vdots \\ x_M & \dots & r_1 & \dots & r_U \end{bmatrix}$ TSMI -- an algorithm -- an odor -- a formula -- ten -- being shown -- a performance index -- Q -- direct -- minimizing. However, α is the weighting constant of $0 < \alpha \leq 1$.

[0070]

[Equation 10]

$$Q(i) = \sum_{i=1}^G \alpha^{G-i} |e(i)|^2$$

[0071] Furthermore, the gradient vector about the weight Y of a formula 7 is set with zero, and the least square of a performance index Q is obtained like a formula 11. This formula 11 shows the formula for updating weight $Y(G)$. However, G is time amount (thump rig time amount), and G shows the count of updating of Weight Y (number of steps).

[0072]

[Equation 11]

$$Y(G) = B^{-1}(G) b(G)$$

[0073] Here, a formula 12 and a formula 13 are shown for B in a formula 11, and b .

[0074]

[Equation 12]

$$B = \sum_{i=1}^G \alpha^{G-i} Z(i) Z^H(i)$$

[0075]

[Equation 13]

$$b(G) = \sum_{i=1}^G \alpha^{G-i} z(i) r_0^*(i)$$

[0076] (The 2nd operation gestalt) Although the example which adopted the generator 70 was explained with the above-mentioned 1st operation gestalt in order to generate delay signal R (i) and (U delay signals), you may make it generate delay signal R (i) using the preamble signal outputted not only from this but from the generator 60. The configuration in this case is shown in drawing 3 and drawing 4.

[0077] Drawing 3 is the block diagram showing the configuration of the adaptive array antenna of the MMSE method of a **** 2 operation gestalt, and drawing 4 is drawing showing the detail of the delay circuit in drawing 3 (henceforth a delay circuit 80). With the **** 2 operation gestalt, as shown in drawing 3, while the generator 60 shown in drawing 1 is deleted, the delay circuit 80 is adopted. In drawing 3, the same sign as the sign in drawing 1 shows the same object or a substantial same object.

[0078] A delay circuit 80 is arranged between a generator 60 and a multiplier 53, and outputs delay signal R (i) stated with the above-mentioned 1st operation gestalt in response to the preamble signal outputted from the generator 60.

[0079] Specifically, a delay circuit 80 is the delay signal r1 (i) with which the series connection of the delay machines (Z-1) 801, 802, and 803 and the --80U is carried out, it is constituted, and the delay machines 801, 802, and 803 and --80U correspond, respectively as shown in drawing 4, and r2 (i). -- rU (i) is outputted to MMSE computing-element 40A and a multiplier 53. Other actuation and effectiveness are the same as the above-mentioned 1st operation gestalt.

[0080] (The 3rd operation gestalt) Although the adaptive array antenna of an MMSE method explained the example which adopted the pudding AMBURU signal of an OFDM signal as a signal on a time-axis with the above-mentioned 1st and 2nd operation gestalt, you may make it adopt each discrimination signal which carried out FFT processing (frequency judgment) of the pudding bull signal of not only this but an OFDM signal. The configuration in this case is shown in drawing 5 - drawing 8. It is ***** with which drawing 5 is drawing showing the configuration of the adaptive array antenna of a **** 3 operation gestalt, and drawing 6 indicates the detail configuration of the FFT circuit 83 in drawing 5 to be. Drawing 7 is drawing showing actuation of the delay circuit 90 of drawing 5, and drawing 8 is drawing showing actuation of the FFT circuit in drawing 6.

[0081] With the **** 3 operation gestalt, as shown in drawing 5, MMSE arithmetic circuit 40B is replaced with and adopted as MMSE arithmetic circuit 40A in drawing 1, and Multipliers 201-20M are replaced with and adopted as the multipliers 21-2M in drawing 1. Multipliers 510-530 are replaced with and adopted as the multipliers 51-53 in drawing 1. Furthermore, the FFT circuits 801-80M, and 83 and 84 are added. The FFT circuit 801 carries out FFT processing of the pudding AMBURU signal of the receiving OFDM signal x1 of an antenna element 11 (i). The FFT circuit 801 samples only N (N is the natural number) time as every [of the above-mentioned pudding AMBURU signal] effective symbol (refer to drawing 17) (analog to digital conversion), carries out FFT processing based on each sampling signal, and, specifically, is the discrimination signal ft1 for every frequency (1), and ft1 (2). -- ft1 (N) may be outputted. Here, they are the discrimination signal ft1 (1) and ft1 (2). -- ft1 (N) can be summarized and can be expressed with a formula 14. Moreover, N is the count of a sampling of the above-mentioned effective symbol, and is the point size of FFT of the above-mentioned effective symbol.

[0082]

[Equation 14] As substantially as the FFT circuit 801, similarly, the FT1(i) =[ft1(1) ft1(2) ft1(3) -- ft1 (N)] TFFT circuit 802 carries out FFT processing of the pudding AMBURU signal of the receiving OFDM signal x1 of an antenna element 11 (i), and is the discrimination signal ft2 for every frequency (1), and ft2 (2). -- ft2 (N) is outputted. Furthermore, the discrimination signal ft2 (1), ft2 (2) -- ft2 (N) is summarized and can be expressed with a formula 15.

[0083]

[Equation 15] $FT2(i) = [ft2(1) \ ft2(2) \ ft2(3) \ \dots \ ft2(N)]$ TFFT circuit 80M carry out FFT processing of the pudding AMBURU signal of the receiving OFDM signal xM of antenna element 1M (i) similarly substantially with the FFT circuit 801, and are the discrimination signal ftM for every frequency (1), and $ftM(2)$. $ftM(N)$ is outputted. Furthermore, the discrimination signal $ftM(1)$, $ftM(2)$ \dots $ftM(N)$ is summarized and can be expressed with a formula 16.

[0084]

[Equation 16] $FTM(i) = [-ftM(1) \ ftM(2) \ ftM(3) \ \dots \ ftM(N)]$ $\rightarrow T$ here \rightarrow a **** 3 operation gestalt $\rightarrow FT1(i)$, $FT2(i)$, and \rightarrow [0085] made into discrimination signal $X(i)'$ as $FTM(i)$ is summarized and it is shown in a formula 17

[Equation 17] $X = (-i) \rightarrow \rightarrow' = [-FT \text{ one } (-i) \rightarrow \rightarrow FT \text{ two } (-i) \rightarrow \rightarrow FTM(-i) \rightarrow]$ $\rightarrow T$ next \rightarrow a multiplier $\rightarrow 201 - 20 \rightarrow M$ the antenna weight WH discrimination signal $X(i)'$ multiplication carrying out. That is, a multiplier 201 obtains a result ($w1*FT1(i)$) in quest of the product of antenna weight $w1*$ and $FT1(i)$. A multiplier 202 obtains a result ($w2*FT2(i)$) in quest of the product of antenna weight $w2*$ and $FT2(i)$. Furthermore, multiplier 20M obtain a result ($wM*FTM(i)$) in quest of the product of antenna weight $wM*$ and $FTM(i)$.

[0086] next \rightarrow an adder (sigma) $\rightarrow 300 \rightarrow$ a multiplier $\rightarrow 201 - 20 \rightarrow M$ depending \rightarrow a result ($w1*FT1(i)$) $\rightarrow (-w \text{ two } * FT \text{ two } (-i) \rightarrow) \rightarrow (wM*FTM(i)) \rightarrow$ a frequency \rightarrow every \rightarrow adding \rightarrow things \rightarrow an antenna \rightarrow weight $\rightarrow W$ discrimination \rightarrow a signal $\rightarrow X(-i) \rightarrow'$ an inner product \rightarrow being shown \rightarrow an inner product \rightarrow a signal $\rightarrow WHX(-i) \rightarrow'$ asking.

[0087] Incidentally, as inner product signal $WHX(i)'$, as shown in a formula 18, the inner product signal of the N individual $fx1(1) \ fx2(2) \ \dots \ fxM(N)$ is packed. Furthermore, for example, $fx1(1)$ can express an inner product signal with a formula 19, and the inner product signal $fx2(2)$ can be expressed with a formula 20. Furthermore, the inner product signal $fxM(N)$ can be expressed with a formula 21.

[0088]

[Equation 18] $WHX(i)' = [fx1(1) \ fx2(2) \ \dots \ fxM(N)] \ T$ [0089]

[Equation 19] $fx1(1) = w1* \text{ and } ft1(1) + w2*, \ ft2(1) \rightarrow wM*, \ ftM(1)$

[0090]

[Equation 20] $fx2(2) = w1* \text{ and } ft1(2) + w2*, \ ft2(2) \rightarrow wM*, \ ftM(2)$

[0091]

[Equation 21] $fxM(N) = w1* \text{ and } ft1(N) + w2*, \ ft2(N) \rightarrow wM*, \ ftM(N)$

Next, delay circuits 90 are the delay preamble signals OF ($t+tS$), OF ($t+2, tS$), and OF ($t+3, tS$) over this preamble signal $r0(i)$, in response to the fact that the preamble signal $r0$ of an OFDM signal (i) and the (request known signal) from a generator 60, as shown in drawing 6. \rightarrow OF ($t+p-tS$) is generated.

[0092] However, tS is the time amount which shows the sampling period of the FFT circuits 801-80M, and ($p+1$) is the count of the sampling at the time of sampling the guard interval GI of an OFDM symbol by time amount tS .

[0093] Thereby, they are the delay preamble signals OF ($t+tS$) and OF ($t+2, tS$). \rightarrow OF ($t+p-tS$) has a time delay shorter than the guard interval period TG to the preamble signal $r0(i)$, respectively. Furthermore, as the number of a delay preamble signal, it is the maximum number defined with the guard interval period TG and a sampling period tS [$p=(TG/tS)-1$].

[0094] Here the delay preamble signal OF ($t+tS$) As shown in drawing 7, by the signal which delayed only time amount tS to the preamble signal $r0(i)$ the delay preamble signal OF ($t+2, tS$) It is the signal which delayed only time amount 2 tS to the preamble signal $r0(i)$, and the delay preamble signal OF ($t+3, tS$) is a signal which delayed only time amount 3 and tS to the preamble signal $r0(i)$. The delay preamble signal OF ($t+p-tS$) is a signal which delayed only time amount $p-tS$ to the preamble signal $r0(i)$.

[0095] Next, the FFT circuits 83 are the delay preamble signals OF ($t+tS$), OF ($t+2, tS$), and OF ($t+3, tS$) from a delay circuit 90, as shown in drawing 6. \rightarrow Each effective symbol of OF ($t+p-tS$) is sampled with a sampling period tS in juxtaposition, and FFT processing is carried out by the

sampling signal. Specifically, the FFT circuits 83 are the FFT processing sections 831, 832, and 833. — It has 83p, and as shown in drawing 8, the FFT processing section 831 carries out FFT processing of the effective symbol of the delay preamble signal OF (t+tS) with a sampling period tS, and outputs delayed discrimination signal R (1). However, delayed discrimination signal R (1) can be expressed with a formula 22. This delayed discrimination signal R (1) has a signal component for every frequency.

[0096]

[Equation 22] $R(1) = \frac{1}{N} \sum_{n=1}^N f_1(1) f_1(2) f_1(3) \dots f_1(N) \dots T$ — the FFT processing section 832 outputs delayed discrimination signal R (2) shown in a formula 23 again by carrying out FFT processing of the effective symbol of the delay preamble signal OF (t+2, tS) with a sampling period tS, as shown in drawing 8. This delayed discrimination signal R (2) has a signal component for every frequency. Furthermore, FFT processing section 83p outputs delayed discrimination signal R (p) shown in a formula 24 by carrying out FFT processing of the effective symbol of the delay preamble signal OF (t+p-tS) with a sampling period tS, as shown in drawing 8. Delayed discrimination signal R (p) has a signal component for every frequency.

[0097]

[Equation 23] $R = \frac{1}{N} \sum_{n=1}^N f_1(1) f_1(2) f_1(3) \dots f_1(N) \dots T$ — the FFT processing section 832 outputs delayed discrimination signal R (2) shown in a formula 23 again by carrying out FFT processing of the effective symbol of the delay preamble signal OF (t+2, tS) with a sampling period tS, as shown in drawing 8. This delayed discrimination signal R (2) has a signal component for every frequency. Furthermore, FFT processing section 83p outputs delayed discrimination signal R (p) shown in a formula 24 by carrying out FFT processing of the effective symbol of the delay preamble signal OF (t+p-tS) with a sampling period tS, as shown in drawing 8. Delayed discrimination signal R (p) has a signal component for every frequency.

[Equation 24] $R = \frac{1}{N} \sum_{n=1}^N f_p(1) f_p(2) f_p(3) \dots f_p(N) \dots T$ — next — drawing 5 — being shown — FFT — a circuit — 84 — drawing 8 — being shown — as — the preamble signal r0 of the OFDM signal from a generator 60 (i) — (= — the effective symbol of OF (t)) is sampled with a sampling period tS, and FFT processing is carried out by these sampling signal. Thereby, the FFT circuit 84 outputs request discrimination signal r0 (i)', as shown in a formula 25. Request discrimination signal r0 (i)' has a signal component for every frequency.

[0099]

[Equation 25] $r = \frac{1}{N} \sum_{i=1}^N f_0(1) f_0(2) f_0(3) \dots f_0(N) \dots T$ — next — a multiplier — 530 — the product of the signal weight AH and delayed discrimination signal R (i) — taking — an output signal [AHR (i)] — outputting. However, the signal weight A in a **** 3 operation gestalt is shown in a formula 26. In addition, an output signal [AHR (i)] packs the output signal of N individual, and is written.

[0100]

[Equation 26] An adder 520 adds the output signal [AHR (i)] of a multiplier 530, and request discrimination signal r0 (i)' to an $A = [a_1 a_2 \dots a_P]^T$ pan, and outputs an addition signal (r0(i)'+AHR (i)) to it. An adder 510 asks for error [with addition signal (r0(i)'+AHR(i)) and inner product signal / of an adder 30 / WHX (i)'] e (i).

[0101] Here, to MMSE computing-element 40B, discrimination signal X (i)', and delayed discrimination signal R (i) and error e (i) are inputted, and MMSE computing-element 40B updates the signal weight A while updating the antenna weight W like the above-mentioned 1st and 2nd operation gestalt so that error e (i) may be made small based on the SMI method of an MMSE method. Thereby, as inner product signal [of an adder 300] WHX (i)', the component except request discrimination signal r0 (i)' (request known signal) and delayed discrimination signal R (i) (other known signals) becomes a repressed signal among discrimination signal X (i)'. Thereby, the same effectiveness is substantially acquired with the above-mentioned 1st and 2nd operation gestalt.

[0102] In addition, at the above-mentioned 3rd operation gestalt, they are the delay preamble signals OF (t+tS), OF (t+2, tS), and OF (t+3, tS). — Although the example which obtained delayed discrimination signal R (i) based on OF (t+p-tS) was explained, delayed discrimination signal R (i) may be obtained not only based on this but based on request discrimination signal r0 (i)'.

[0103] (The 4th operation gestalt) Although the adaptive array antenna of an MMSE method explained the example which receives an OFDM signal with the above-mentioned 1-3rd operation gestalt, the adaptive array antenna of not only this but an MMSE method may be

applied to a CDMA communication link. The configuration in this case is shown in drawing 9 .

[0104] The matched filter 100 and the RAKE composition machine 110 are added and constituted from drawing 9 by the circuit shown in drawing 3 . Furthermore, it replaces with the delay circuit 80 shown in drawing 3 , and delay circuit 80A is adopted. In drawing 9 , the same sign as the sign in drawing 1 shows the same object or a substantial same object. however — each — ANTENANA component 11 — 1M — an OFDM signal — replacing with — a CDMA signal — receiving — the receiving CDMA signal $x_1(i)$, $x_2(i)$, and — $x_M(i)$ is outputted.

[0105] Next, actuation of a **** 4 operation gestalt is explained with reference to drawing 10 . Hereafter, four antenna elements 11-14 are adopted, and the example to which antenna elements 11-14 output each is explained. A matched filter 100 performs correlation detection with the pilot signal (known signal) r_0 from each and a generator 60 for the receiving CDMA signal $x_1(i)$, $x_2(i)$, $x_3(i)$, and $x_4(i)$ in juxtaposition.

[0106] concrete — a matched filter 100 — the 1- it has the 4th matched filter section (not shown). The 1st matched filter section carries out correlation detection of the receiving CDMA signal $x_1(i)$ and a pilot signal $r_0(i)$, and outputs a correlation signal (refer to drawing 10 (a)), and the 2nd matched filter section considers correlation detection with a pilot signal $r_0(i)$ as receiving CDMA signal $x_2(i)$, and outputs a correlation signal (refer to drawing 10 (b)).

[0107] The 3rd matched filter section carries out correlation detection of the receiving CDMA signal $x_3(i)$ and a pilot signal $r_0(i)$, and outputs a correlation signal (refer to drawing 10 (c)), and the 4th matched filter section carries out correlation detection of the receiving CDMA signal $x_4(i)$ and a pilot signal $r_0(i)$, and outputs a correlation signal (refer to drawing 10 (d)). However, by drawing 10 (a) - (d), an axis of ordinate shows a correlation value, and an axis of abscissa shows time amount by it.

[0108] here — a matched filter 100 — the 1- the correlation signal from the 4th matched filter section is added, and the delay information on the basis of the time of the input of a pilot signal $r_0(i)$ and a (request signal) is acquired based on the addition result. This delay information shows the delay signal of a time delay shorter than desired time amount among receiving CDMA signal $x_1(i)$ - $x_4(i)$. The example shown in drawing 10 (e) shows the example of ** from which td_1 , td_2 , td_3 - td_6 are obtained as delay information. Then, using the delay information td_1 - td_6 , delay circuit 80A outputs delay signal $R(i)$ and (other known signals), as shown in drawing 10 (f).

[0109] That is, delay circuit 80A is $r_0(t+td_1)$, $r_0(t+td_2)$, and $r_0(t+td_6)$. — $r_0(t+td_6)$ is outputted. For example, to a pilot signal $r_0(i)$, only the time delay td_1 is delayed and, as for $r_0(t+td_2)$, only the time delay td_2 is delayed by $r_0(t+td_1)$ to a pilot signal $r_0(i)$. As for $r_0(t+td_6)$, only the time delay td_6 is delayed to a pilot signal $r_0(i)$. Other actuation is substantially [as the circuit shown in drawing 3] the same.

[0110] By the above, it is the receiving CDMA signal $x_1(i)$ as an inner product signal WHX from an adder (sigma). — A repressed signal is acquired for the component except a pilot signal $r_0(i)$ (request signal) and its delay signals $r_0(t+td_1)$ - $r_0(t+td_6)$ (other known signals) among $x_M(s)$ (i). And the RAKE composition machine 110 will perform a RAKE composition recovery using the inner product signal WHX concerned. if a signal required for a RAKE composition recovery is prepared here as delay signals $r_0(t+td_1)$ - $r_0(t+td_6)$ — an oppression of a signal unnecessary for a RAKE composition recovery sake — null — a point can be formed. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an MMSE method can be held down like the above-mentioned 1st operation gestalt.

[0111] In addition, the adaptive array antenna of an MMSE method is applied to the communication link of a CDMA method, and although the example which acquires the delay information on the CDMA input signal $X(i)$ with a matched filter 100 was shown, you may make it acquire the delay information on the receiving OFDM signal of not only this but the above-mentioned 1st and 2nd operation gestalt with a matched filter 100 in the above-mentioned 4th operation gestalt.

[0112] (The 5th operation gestalt) Although the 2 above-mentioned operation gestalten explained the example which set up beforehand a request known signal and other known signal ****, you may make it choose a request known signal and other known signals among delay signal $R(i)$ not only according to this but according to the receiving OFDM signal $X(i)$.

[0113] The configuration in this case is shown in drawing 11 and drawing 12. Drawing 11 shows the configuration of the adaptive array antenna of the MMSE method in a **** 5 operation gestalt. Drawing 12 shows the detail configuration of the request signal selection circuitry in drawing 11 (following and request signal selection circuitry 130).

[0114] As the adaptive array antenna of the MMSE method of a **** 5 operation gestalt is shown in drawing 11, the request signal selection circuitry 130 is added to the circuit shown in drawing 3. In drawing 11, the same sign which drawing 3 shows shows the same object or a real target the same object.

[0115] A delay circuit 90 receives the preamble signal r_0 from a generator 60 (i), and is the delay preamble signals $OF(t+tS)$ and $OF(t+2, tS)$. — $OF(t+U-tS)$ is generated. However, U is the delay preamble signal [as opposed to / are the natural number and / the preamble signal r_0 (i)] $OF(t+tS)$. — Each time delay of $OF(t+U-tS)$ is short compared with the guard interval period TG of an OFDM signal.

[0116] the receiving OFDM signal $X(i)$ and delay preamble signal $OF(t+tS)$ — $OF(t+U-tS)$ input into the request signal selection circuitry 130 — having — the request signal selection circuitry 130 — the receiving OFDM signal $X(i)$ — responding — delay preamble signal $OF(t+tS)$ — request known signal $r_0(i)$ and delay signal $R(i)$ are chosen among $OF(s)(t+U-tS)$.

[0117] Specifically, the request signal selection circuitry 130 consists of Correlators 131a–131c, 132a–132c, 133a–133c, 134a–134c, adders (sigma) 135a–135c, a maximum judging machine 136, and a selection circuitry 137, as shown in drawing 12.

[0118] Next, actuation of a **** 5 operation gestalt is explained with reference to drawing 12. The example which adopted only four antenna elements called antenna elements 11–14, and adopted three delay preamble signals of the delay preamble signals $OF(t+tS)$, $OF(t+2, tS)$, and $OF(t+3, tS)$ hereafter is explained. First, antenna elements 11–14 output the receiving OFDM signal $x_1(i)$, $x_2(i)$, $x_3(i)$, and $x_4(i)$, respectively.

[0119] Next, correlator 131a performs correlation detection of the delay preamble signal $OF(t+tS)$ and the receiving OFDM signal $x_1(i)$, and correlator 132a performs correlation detection of the delay preamble signal $OF(t+tS)$ and receiving OFDM signal $x_2(i)$. Correlator 133a performs correlation detection of the delay preamble signal $OF(t+tS)$ and the receiving OFDM signal $x_3(i)$, and correlator 134a performs correlation detection of the delay preamble signal $OF(t+tS)$ and the receiving OFDM signal $x_4(i)$.

[0120] Adder 135a adds the correlation detecting signal from each of Correlators 131a, 132a, 133a, and 134a, and outputs an addition signal. Here, the addition signal of adder 135a shows correlation with the delay preamble signal $OF(t+tS)$, the receiving OFDM signal $x_1(i)$, $x_2(i)$, $x_3(i)$, and $x_4(i)$.

[0121] Next, correlator 131b performs correlation detection of the delay preamble signal $OF(t+2, tS)$ and the receiving OFDM signal $x_1(i)$, and correlator 132b performs correlation detection of the delay preamble signal $OF(t+2, tS)$ and receiving OFDM signal $x_2(i)$. Correlator 133b performs correlation detection of the delay preamble signal $OF(t+2, tS)$ and the receiving OFDM signal $x_3(i)$, and correlator 134b performs correlation detection of the delay preamble signal $OF(t+2, tS)$ and the receiving OFDM signal $x_4(i)$.

[0122] Adder 135b adds the correlation detecting signal from each of Correlators 131b, 132b, 133b, and 134b, and outputs an addition signal. The addition signal of adder 135b shows correlation with the delay preamble signal $OF(t+2, tS)$, the receiving OFDM signal $x_1(i)$, $x_2(i)$, $x_3(i)$, and $x_4(i)$.

[0123] Next, correlator 131c performs correlation detection of the delay preamble signal $OF(t+3, tS)$ and the receiving OFDM signal $x_1(i)$, and correlator 132c performs correlation detection of the delay preamble signal $OF(t+3, tS)$ and receiving OFDM signal $x_2(i)$. Correlator 133c performs correlation detection of the delay preamble signal $OF(t+3, tS)$ and the receiving OFDM signal $x_3(i)$, and correlator 134c performs correlation detection of the delay preamble signal $OF(t+3, tS)$ and the receiving OFDM signal $x_4(i)$.

[0124] Adder 135c adds the correlation detecting signal from each of Correlators 131c, 132c, 133c, and 134c, and outputs an addition signal. The addition signal of adder 135c shows correlation with the delay preamble signal $OF(t+3, tS)$, the receiving OFDM signal $x_1(i)$, $x_2(i)$, $x_3(i)$, and $x_4(i)$.

(i), and $x_4(i)$.

[0125] Next, the maximum judging machine 136 judges the addition signal (henceforth a maximum addition signal) which serves as maximum among each addition signal from Adders 135a-135c, and outputs the maximum recognition signal which shows this maximum addition signal to a selection circuitry 137. Among the delay preamble signals OF ($t+tS$), OF ($t+2, tS$), and OF ($t+3, tS$), a selection circuitry 137 chooses the delay preamble signal corresponding to a maximum recognition signal as request known signal $r(i)$, and outputs it. Furthermore, a selection circuitry 137 outputs two delay preamble signals except the delay preamble signal corresponding to a maximum recognition signal as other known signals $R(i)$ among the delay preamble signals OF ($t+tS$), OF ($t+2, tS$), and OF ($t+3, tS$). Other actuation is substantially [as the above-mentioned 2nd operation gestalt] the same.

[0126] In addition, in the above-mentioned 5th operation gestalt, although the example which adopted four antenna elements 11-14 was explained, if the number of not only this but an antenna element is two or more pieces, it is good without limit. Furthermore, although the above-mentioned 5th operation gestalt explained per [which adopted three delay preamble signals OF ($t+tS$), OF ($t+2, tS$), and OF ($t+3, tS$)] example, any number of numbers of not only this but a delay preamble signal are good.

[0127] In addition, as correlator shown in a **** 5 operation gestalt, various correlators, such as slide correlator and a matched filter, may be applied in operation of this invention.

[0128] (The 6th operation gestalt) With a **** 6 operation gestalt, the circuit where the equalizing circuit (henceforth an equalizing circuit 120) was added is adopted as the circuit of the above-mentioned 2nd operation gestalt, by the equalizing circuit 120, others and a known signal are oppressed among the inner product signals WHX of an adder 30 (i), and the repressed signal is outputted as an output signal. The configuration in this case is shown in drawing 13 and drawing 14.

[0129] Drawing 13 is drawing showing the configuration of the adaptive array antenna of the MMSE method of a **** 6 operation gestalt. Drawing 14 shows the detail configuration of the equalizing circuit 120 in drawing 13. In drawing 13, the same sign in drawing 3 shows the same object or a real target the same object.

[0130] With the **** 6 operation gestalt, the adaptive array antenna of an MMSE method is applied to the QPSK communication mode instead of an OFDM communication mode. For this reason, antenna elements 11-1M receive a QPSK signal (pilot signal).

[0131] Therefore, antenna elements 11-1M are replaced with the receiving OFDM signal $X(i)$, and output the receiving QPSK signal $X(i)$, respectively. Moreover, the generating circuit 60 outputs the pilot signal r_0 of a QPSK signal (i) as a request known signal, and a delay circuit 90 outputs delay pilot signal $R(i)$ for which only the request period was delayed to the pilot signal r_0 of a QPSK signal (i) as other known signals. MMSE computing-element 40A updates the antenna weight WH and the signal weight AH similarly substantially with the above-mentioned 2nd operation gestalt. Moreover, the component excluding [an adder (sigma) 30] the both sides of a request pilot signal (request known signal) and its delay pilot signal (other known signals) among the receiving QPSK signals $X(i)$ outputs a repressed signal as an inner product signal WHX. Moreover, the equalizing circuit 120 consists of delay machines (Z-1) 121-124, multipliers 125-128, and adders 129 and 130, as shown in drawing 14. Next, actuation of the equalizing circuit 120 of a **** 6 operation gestalt is explained with reference to drawing 14 and drawing 15.

[0132] Hereafter, as shown in drawing 15 (a), the example as which total with request pilot signal QP1 and the delay pilot signals QP2-QP5 was adopted is explained as an inner product signal WHX of an adder (sigma) 30.

[0133] Since four delay pilot signals of the delay pilot signals QP2-QP5 are adopted here, the signal weight (henceforth signal weight $A(G)$) of MMSE computing-element 40A in a **** 6 operation gestalt can be expressed with a formula 27. G is sampling timing (updating timing) ($G=t_1, t_2, t_3 \dots$). Moreover, drawing 15 (b) shows the output of the delay machines 121-124 in timing t_1-t_5 .

[0134]

[Equation 27] $A(G) = \dots a_1 [] (G) \dots a_2 [] (G) \dots a_3 (G) \dots a_4 (G) \dots T \dots$ the QPSK

symbol ZA shown in drawing 15 (a) is first inputted into the delay machine 121 through an adder 130 to timing t1. That is, an equalizing circuit 120 can output the QPSK symbol ZA to timing t1. [0135] Next, to timing t2, as shown in drawing 15 (b), the delay machine 121 outputs the QPSK symbol ZA to the delay machine 122 while outputting the QPSK symbol ZA to a multiplier 127. Then, a multiplier 128 carries out the multiplication of signal weight $a_1(t_2) *$ to the QPSK symbol ZA, and outputs a multiplication signal ($a_1(t_2) * ZA$) to an adder 129.

[0136] Here, as the above-mentioned 1st operation gestalt described, signal weight $a_1(t_2) *$ (signal weight AH) is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZA1 {delay signal R (i)} on the basis of the QPSK symbol ZA {the preamble signal r0 (i)}. For this reason, a multiplication signal ($a_1(t_2) * ZA$) becomes equal to the QPSK symbol ZA1 ($ZA1 = a_1(t_2) * ZA$).

[0137] Thereby, a multiplier 128 can output the multiplication signal ZA1 to an adder 130 through an adder 129. Moreover, the QPSK symbols ZB and ZA1 are inputted into an adder 130 as an inner product signal WHX of an adder (sigma) 30. An adder 130 outputs a differential signal (= ZB) to the delay machine 121 in quest of the difference of the QPSK symbols ZB and ZA1 and the multiplication signal ZA1. That is, an equalizing circuit 120 can output the QPSK symbol ZB to timing t2.

[0138] Next, to timing t3, the delay machine 122 outputs the QPSK symbol ZA to the delay machine 123 while outputting the QPSK symbol ZA to a multiplier 127, as shown in drawing 15 (b). Then, a multiplier 127 carries out the multiplication of signal weight $a_2(t_3) *$ to the QPSK symbol ZA, and outputs a multiplication signal ($a_2(t_3) * ZA$) to an adder 129.

[0139] Here, as the above-mentioned 1st operation gestalt described, signal weight $a_2(t_3) * ZA$ (signal weight AH) is calculated so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZA2 {delay signal R (i)} on the basis of the QPSK symbol ZA {the preamble signal r0 (i)}. For this reason, a multiplication signal ($a_2(t_3) * ZA$) becomes equal to the QPSK symbol ZA2 ($ZA2 = a_2(t_3) * ZA$). Therefore, a multiplier 127 outputs the QPSK symbol ZA2 to an adder 129.

[0140] Moreover, the delay machine 121 outputs the QPSK symbol ZB to the delay machine 122 while outputting the QPSK symbol ZB to a multiplier 128, as shown in drawing 15 (b). A multiplier 128 carries out the multiplication of signal weight $a_1(t_3) *$ to the QPSK symbol ZB, and outputs a multiplication signal ($a_1(t_3) * ZB$) to an adder 129.

[0141] Here, as the above-mentioned 1st operation gestalt described, signal weight $a_1(t_3) *$ (signal weight AH) is called for so that MMSE computing-element 40A may show the phase contrast and the amplitude difference of the QPSK symbol ZB1 {delay signal R (i)} on the basis of the QPSK symbol ZB {the preamble signal r0 (i)}.

[0142] Therefore, a multiplication signal ($a_1(t_3) * ZB$) becomes equal to the QPSK symbol ZB1 ($ZB1 = a_1(t_3) * ZB$). Therefore, a multiplier 127 can output the multiplication signal ZB1 to an adder 129.

[0143] Here, an adder 129 adds the multiplication signal ZB1 of a multiplier 127, and the QPSK symbol ZA2 of an adder 129, and outputs an addition signal ($ZB1 + ZA2$) to an adder 130. The QPSK symbols ZC, ZB1, and ZA2 are inputted into an adder 130 as an inner product signal WHX of an adder (sigma) 30, and an adder 130 asks for the difference of the QPSK symbols ZC, ZB1, and ZA2 and an addition signal ($ZB1 + ZA2$), and outputs a differential signal ZC to the delay machine 121.

[0144] That is, an equalizing circuit 120 can output the QPSK symbol ZC to timing t3. Hereafter, an equalizing circuit 120 operates similarly substantially with above-mentioned actuation, by timing t4, outputs the QPSK symbol ZD and outputs the QPSK symbol ZE to timing t5.

[0145] By the above, an equalizing circuit 120 can output only QPSK symbol ZA-ZD like ****. If it puts in another way, as an inner product signal WHX of an adder (sigma) 30, total with request pilot signal QP1 and the delay pilot signals QP2-QP5 will be inputted into an equalizing circuit 120, it will oppress the delay pilot signals QP2-QP5, and will output only request pilot signal QP1.

[0146] In addition, although the above-mentioned 6th operation gestalt explained the example which applied the adaptive array antenna of an MMSE method to the QPSK communication

mode, you may apply not only to this but to an OFDM communication mode.

[0147] Furthermore, it is in charge of operation of this invention, and various communication modes may be adopted in addition to an OFDM communication mode, a CDMA communication mode, the communication mode using a QPSK modulation, etc.

[0148] In addition, although the 1st – the 6th operation gestalt explained the example which adopted the SMI algorithm of an MMSE method with the MMSE computing elements 40A and 40B, other algorithms may be adopted as long as it is an MMSE method.

[0149] When an interference wave comes from the same direction as a request signal in the (7th operation gestalt) and time in the adaptive array antenna of the MMSE method stated with the above-mentioned 1st operation gestalt, there is a problem that the interference wave cannot be oppressed. namely, in the adaptive array antenna of the MMSE method stated with the above-mentioned 1st operation gestalt Although the component except the preamble signal $r_0(i)$ and delay signal $R(i)$ becomes a repressed signal among the receiving OFDM signals $X(i)$, the inner product signal WHX of an adder 30 When a delay-GI outside signal (interference wave) comes from the same direction as the preamble signal $r_0(i)$, the GI delay signal can be controlled.

[0150] It is well-known to oppress without distinguishing the request signal and interference wave which are contained in it in an incoming wave component in the adaptive array antenna of the conventional PI method. Then, in a **** 7 operation gestalt, it explains per [oppresses the interference wave which accomplished paying attention to the adaptive array antenna of the conventional PI method, and prevents oppression of the both sides of a request wave and the delay signal in GI, and comes from the same direction as a request signal and it is made to raise the communication link engine performance] example. The configuration in this case is shown in drawing 16 .

[0151] The adaptive array antenna of PI method is antenna elements 11–14 and a multiplier 21. – It consists of 2M, an adder (sigma) 30, the PI computing element 41, adder 51A, multiplier 53A, and delay circuit 80A. In drawing 16 , the same sign as the sign in drawing 1 shows the same object or a substantial same object.

[0152] Delay circuit 80A outputs this preamble signal $r_0(i)$ and delay signal $R(i)$ in response to the preamble signal $r_0(i)$ stated with the above-mentioned 1st operation gestalt. Hereafter, the output signal of delay circuit 80A is called output signal $R(i)'$.

[0153] However, like ****, the time delay of delay signal $R(i)$ to a preamble signal is short compared with the period TG of the guard interval GI of an OFDM symbol, and sets the number (sample point size) of delay signal $R(i)$ to 16.

[0154] Multiplier 53A carries out the multiplication of the signal weight AH to output signal $R(i)'$, and searches for a multiplication signal $\{AHR(i)'\}$. Adder 51A adds a multiplication signal $\{AHR(i)'\}$ and the inner product signal WHX of an adder 30 (i), and asks for an addition reference sign $(WHX(i)+AHR(i)')$.

[0155] Addition reference-sign $(WHX(i)+AHR(i)')$ and output signal $R(i)'$ and the receiving OFDM signal $X(i)$ are inputted into the PI computing element 41, and the PI computing element 41 updates the antenna weight W and the signal weight A so that power $|WHX(i)+AHR(i)'|^2$ of an addition reference sign may be made into min. At this time, the signal weight A turns into weight which negates output signal $R(i)'$ among the signal components contained in the inner product signal $WHX(i)$, and the antenna weight W turns into weight which makes min power of the interference wave component contained in the receiving OFDM signal $X(i)$.

[0156] If it puts in another way, the PI computing element 41 will update the antenna weight W and the signal weight A so that power of the component except output signal $R(i)'$ may be made into min among the power $(WHX(i)+AHR(i)')$ of an addition reference sign.

[0157] In drawing 17 , the result of a simulation when a request signal and a delay-GI outside signal come from the same is shown. In drawing 17 , when the 1st – the 5th wave come, the directivity after actuation of the adaptive array antenna of the adaptive array antenna of PI method and an MMSE method is shown. The receiving include angle [deg] of the received [a right longitudinal shaft] electric wave on the basis of the adaptive array antenna of an MMSE method and a left-vertical shaft are the receiving include angles [deg] of the received electric wave on the basis of the adaptive array antenna of PI method. An axis of abscissa is an

oppression ratio (dB).

[0158] In drawing 17, since antenna gain differs, it expresses with the adaptive array antenna of an MMSE method, and the adaptive array antenna of PI method that the gain of the direction of delay ***** in GI becomes the same.

[0159] Here, the chain line shows the result of the simulation which used the adaptive array antenna of an MMSE method. A continuous line shows the result of the simulation which used the adaptive array antenna of PI method. Although the delay-GI outside signal of the same direction as a request signal is not oppressed in the adaptive array antenna of an MMSE method so that drawing 17 may show, the delay-GI outside signal of the same direction as a request signal is oppressed in the adaptive array antenna of PI method.

[0160] (The 8th operation gestalt) With the ***** 8 operation gestalt, as shown in drawing 18, low pass filters 420-425 are added to the configuration which the above-mentioned 7th operation gestalt shows. In drawing 18, low pass filters 420-424 search for the OFDM signal signal of a narrow-band based on the receiving OFDM signal X (i).

[0161] Low pass filters 420-424 output a narrow-band OFDM signal signal by taking out only the component (referring to drawing 19) of the predetermined frequency band among the receiving OFDM signals X (i). That is, the OFDM signal signal of a narrow-band turns into a signal which narrowed the frequency band of the receiving OFDM signal X (i).

[0162] A low pass filter 425 searches for a narrow-band preamble signal based on the preamble signal r0 (i). that is, the low pass filter 425 — the preamble signal r0 (i) — a narrow-band preamble signal is outputted by taking out only the component of the predetermined frequency band inside.

[0163] In connection with this, delay circuit 80A searches for the delay signal of U (drawing 19 8) individual which has a different time delay to a narrow-band preamble signal, and outputs the both sides of this delay signal and a narrow-band preamble signal as output signal R(i)'. However, the time delay of the delay signal over a preamble signal is short like ***** compared with the period TG of the guard interval GI of an OFDM symbol.

[0164] Here, among output signal R(i)', the number of adoption of a delay signal (sample point) can be reduced, if it is decided by the frequency band of the receiving OFDM signal X (i) and the frequency band is narrowed.

[0165] then — ***** — eight — operation — a gestalt — PI — a computing element — 41 — an antenna — weight — W — and — a signal — weight — A — updating — hitting — OFDM — a signal — a signal — replacing with — a narrow-band — OFDM — a signal — a signal — adopting — a preamble — a signal — having been based — an output signal — R — (— i —) — ' — replacing with — a narrow-band — a preamble — a signal — having been based — an output signal — R — (— i —) — ' — adopting. For this reason, not to mention reducing the number of adoption of R (i), it becomes possible about the antenna weight W and the signal weight A to reduce the count of updating, and the computational complexity of renewal of weight can be reduced.

[0166] (The 9th operation gestalt) Although the above-mentioned 3rd operation gestalt explained the adaptive array antenna of the MMSE method which adopted the pudding AMBURU signal of an OFDM signal as a signal on a time-axis, a ***** 9 operation gestalt explains per adaptive array antenna of PI method which adopted each discrimination signal which carried out FFT processing (frequency judgment) of the pudding bull signal of not only this but an OFDM signal. The configuration in this case is shown in drawing 20.

[0167] The adaptive array antenna of PI method consists of antenna elements 11-14, a multiplier 201-204, an adder (sigma) 300, the FFT circuits 801-804, the FFT circuit 834, the PI computing element 42, adder 510A, multiplier 530A, and delay circuit 80A. In drawing 20, the same sign as the sign in drawing 5 shows the same object.

[0168] As the above-mentioned 8th operation gestalt described, delay circuit 80A combines the preamble signal r0 (i) and delay signal R (i), and outputs them as output signal R(i)'. The FFT circuit 834 samples each effective symbol of the preamble signal r0 (i) and delay signal R (i) with a sampling period tS in juxtaposition, carries out FFT processing by the sampling signal, and outputs the discrimination signal RFT (i).

[0169] Multiplier 530A carries out the multiplication of the signal weight AH to the discrimination signal RFT (i), and searches for a multiplication signal {AHRFT (i)}. Adder 510A adds multiplication signal {AHRFT (i)} and inner product signal [of an adder 300] WHX (i)', and asks for an addition reference sign (WHX(i)'+AHRFT (i)).

[0170] Discrimination signal X (i)', and an addition reference sign (WHX (i) ' +AHRFT (i)') and the discrimination signal RFT (i) are inputted into the PI computing element 42, and the PI computing element 42 updates the antenna weight W and the signal weight A so that power |WHX (i)'+AHRFT(i)|² of an addition reference sign may be made into min. At this time, the signal weight A turns into weight which negates the discrimination signal RFT (i) among the signal components contained in inner product signal WHX (i)', and the antenna weight W turns into weight which makes min power of the interference wave component contained in discrimination signal X (i)'.

[0171] If it puts in another way, the PI computing element 42 will update the antenna weight W and the signal weight A so that power of the component except the discrimination signal RFT (i) may be made into min among addition reference signs (WHX (i) ' +AHRFT (i)').

(The 10th operation gestalt) The adaptive array antenna of the SMI method in a **** 10 operation gestalt consists of antenna elements 11 and 12, a generator 60, the FFT circuits 83, 801, and 802, multipliers 201 and 202, an adder (sigma) 300, the phase revolution machine 1000, correlator 1010, a selection circuitry 1020, and a computing element 1030, as shown in drawing 21.

[0172] A computing element 1030 has the matrix-of-correlation presumption machine 1031, the inverse-matrix computing element 1032, the correlation vector presumption machine 1033, and the matrix multiplication machine 1034. In addition, in drawing 21, the same sign in drawing 1 and drawing 2 shows the same object.

[0173] First, FFT processing of the pudding AMBURU signal of the receiving OFDM signal x1 (i) received by the antenna element 11 is carried out in the FFT circuit 801, and the discrimination signal ft1 (1), ft1 (2), ft1 (3), and ft1 (4) are calculated for every frequency. Moreover, FFT processing of the receiving OFDM signal x2 (i) received by the antenna element 12 is carried out in the FFT circuit 802, and the discrimination signal ft2 (1), ft2 (2), ft2 (3), and ft2 (4) are calculated for every frequency. In addition, the figure 1—4 in the parenthesis of a discrimination signal shows the point size of FFT.

[0174] Here, the vector notation of receiving OFDM signal x1(i) x2(i) discrimination signal ft1(1) — ft1 (3) and the discrimination signal ft2(1) —ft2 (3) is carried out as follows.

[0175]

[Equation 28] $X(i) = [x1(i) \ x2(i)]^T$ [0176]

[Equation 29] $FT1(i) = [ft1(1) \ ft1(2) \ ft1(3)]^T$ [0177]

[Equation 30] The $FT2(i) = [ft2(1) \ ft2(2) \ ft2(3)]^T$ multiplier 201 asks for the matrix product ($w1*FT1(i)$) of antenna weight $w1*$ and $FT1(i)$, and a multiplier 202 asks for the matrix product ($w2*FT2(i)$) of antenna weight $w2*$ and $FT2(i)$.

[0178] Next, an adder (sigma) 300 adds the matrix product ($w1*FT1(i)$) by multipliers 201 and 202, and ($w2*FT2(i)$) for every frequency. namely, — a matrix — a product ($w1*FT1(i)$) — (— w — two — * — FT — two — (— i —) —) — an antenna — weight — w — one — * — w — two — * — a formula — 31 — 32 — like — a vector — a notation — carrying out — if — an adder (sigma) — 300 — an antenna — weight — W — discrimination — a signal — X — (— i —) — ' — an inner product — being shown — an inner product — a signal — WHX — (— i —) — ' — asking — having. Moreover, as shown in a formula 33, the vector notation of inner product signal WHX (i)' is carried out.

[0179]

[Equation 31]

$X(i)' = [FT1(i) \ FT2(i)]^T$ [0180]

[Equation 32] $W = [w1 \ w2]^T$ [0181]

[Equation 33] $WHX(i)' = [w1*ft1(1)+w2*ft2(1) \ w1*ft1(2)+w2*ft2(2) \ w1*ft1(3)+w2*ft2(3)]^T$, next a generator 60 as a request known signal Generating the preamble signal r0 of an OFDM signal (i), this preamble signal r0 (i) is a signal with which two or more pilot symbols (known signal) were

arranged on the frequency shaft. Moreover, the FFT circuit 83 carries out FFT processing of the preamble signal r0 of an OFDM signal (i), and calculates the request discrimination signal rf1 (1), rf1 (2), and rf1 (3) for every frequency.

[0182] Next, only four sorts of amounts of phases (0degree, θ , 2θ , 3θ) carry out revolution processing of the request discrimination signal rf1 (1), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (1 θ), rf1 (1 2θ), and rf1 (1 3θ) by which revolution processing was carried out, and the request discrimination signal rf1 (1).

[0183] Furthermore, only four sorts of amounts of phases (0 degree, θ , 2θ , 3θ) carry out revolution processing of the request discrimination signal rf1 (2), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (2 θ), rf1 (2 2θ), and rf1 (2 3θ) by which revolution processing was carried out, and the request discrimination signal rf1 (2).

[0184] Moreover, only four sorts of amounts of phases (0degree, θ , 2θ , 3θ) carry out revolution processing of the request discrimination signal rf1 (3), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (3 θ), rf1 (3 2θ), and rf1 (3 3θ) by which revolution processing was carried out, and the request discrimination signal rf1 (3).

[0185] Here, request discrimination signal rf1(1) -rf1 (1 3θ), rf1(2) -rf1 (2 3θ), and rf1(3) -rf1 (3 3θ) are calculated as shown in a formula 34.

[0186]

[Equation 34]

$$BS = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \\ C_{41} & C_{42} & C_{43} \end{bmatrix} \begin{bmatrix} rf1(1) & 0 & 0 \\ 0 & rf1(2) & 0 \\ 0 & 0 & rf1(3) \end{bmatrix}$$

[0187] However, the amount of phases which shows Ctf in a formula 35, the number t indicates the amount of phases to be, and f are numbers which show a frequency. Moreover, they are $C_{11}=C_{12}=C_{13}$, $C_{21}=C_{22}=C_{23}$, and $C_{31}=C_{32}=C_{33}$ with a formula 35.

[0188]

[Equation 35] $C_{tf} = \exp \{-2\pi j - (j-1) - (t-1)/3\}$

Here, the output signal of the phase revolution machine 1000 is equivalent to what combined the output signal of the FFT circuit 84 and the output signal of the FFT circuit 83 which are shown in drawing 5. That is, the FFT circuit 84 generates a time delay shorter than the guard interval period TG to the preamble signal r0 (i) with the phase revolution machine 1000, and plays a role equivalent to carrying out FFT processing of this generated time delay.

[0189] Next, correlator 1010 calculates the correlation value K of the request processing signal BS and discrimination signal X (i)'. In addition, the correlation value K is calculated by the matrix product (BSxX (i) ') of the request processing signal BS and discrimination signal X (i)'.

[0190] Based on the correlation value K, as for a selection circuitry 1020, the request processing signal BSmax with the largest correlation with discrimination signal X (i)' among the request processing signals BS is searched for for every frequency.

[0191] For example, the vector notation of the correlation value K is carried out like a formula 36. The number t indicates the amount of phases to be in the correlation value ktf, and f are numbers which show a frequency among a formula 36.

[0192]

[Equation 36]

$$K = \begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \\ K_{31} & K_{32} \\ K_{41} & K_{42} \end{bmatrix}$$

[0193] First, a selection circuitry 1020 adds the square value (**ktf** 2) of an absolute value for every amount of phases respectively, and searches for the matrix KG which shows in a formula 37 while it calculates each absolute value of the correlation value ktf and calculates the square value (**ktf** 2) of each absolute value.

[0194]

[Equation 37]

$$KG = \begin{bmatrix} |K_{11}|^2 + |K_{12}|^2 \\ |K_{21}|^2 + |K_{22}|^2 \\ |K_{31}|^2 + |K_{32}|^2 \\ |K_{41}|^2 + |K_{42}|^2 \end{bmatrix}$$

[0195] Next, a selection circuitry 1020 searches for the request discrimination signal (henceforth the request discrimination signal MX) corresponding to the amount of phases of maximum for every frequency among Matrices BS while calculating maximum among Matrices KG.

[0196] Here, it is the request discrimination signal rf1 (1). — rf1 (2) — The vector notation of the matrix BS which shows rf1 (3 3theta) is carried out like a formula 38.

[0197]

[Equation 38]

$$BS = \begin{bmatrix} rf1(1) & rf1(2) & rf1(3) \\ rf1(1 \ \theta) & rf1(2 \ \theta) & rf1(3 \ \theta) \\ rf1(1 \ 2\theta) & rf1(2 \ 2\theta) & rf1(3 \ 2\theta) \\ rf1(1 \ 3\theta) & rf1(2 \ 3\theta) & rf1(3 \ 3\theta) \end{bmatrix}$$

[0198] as the maximum of for example, the matrix KG — [— the time of ** k21 ** 2+ ** k22 ** 2] being chosen — the inside of a formula 38 — as the request discrimination signal MX for every frequency (i) — [— rf1 (12theta) rf1 (2 2theta) and rf1(3 2theta)] are chosen.

Furthermore, as request discrimination signals other than the request discrimination signal MX for every frequency (i) are shown in a formula 39 among formulas 38, it considers as the request processing signal BA. However, the request processing signal BA of a formula 39 shows an example as which [rf1 (1 2theta) rf1 (2 2theta) and rf1(3 2theta)] were chosen as a request discrimination signal MX (i).

[0199]

[Equation 39]

$$BA = \begin{bmatrix} rf1(1) & rf1(2) & rf1(3) \\ rf1(1 \ \theta) & rf1(2 \ \theta) & rf1(3 \ \theta) \\ rf1(1 \ 3\theta) & rf1(2 \ 3\theta) & rf1(3 \ 3\theta) \end{bmatrix}$$

[0200] In addition, hereafter, in order to give explanation simply, as shown in a formula 40, the vector notation of the request processing signal BA (i) is carried out, and as shown in a formula 41, the vector notation of the request discrimination signal MX (i) is carried out. The number t indicates the amount of phases to be in the correlation value batf, and f are numbers which show a frequency among a formula 40. In mxt, t is a number which shows the amount of phases among a formula 41.

[0201]

[Equation 40]

$$BA(i) = \begin{bmatrix} ba_{11}(i) & ba_{21}(i) & ba_{31}(i) \\ ba_{12}(i) & ba_{22}(i) & ba_{32}(i) \\ ba_{13}(i) & ba_{23}(i) & ba_{33}(i) \end{bmatrix}$$

[0202]

[Equation 41]

$$MX(i) = \begin{bmatrix} mx_1 & mx_2 & mx_3 \end{bmatrix}$$

[0203] In addition, hereafter, as shown in a formula 42, the vector notation of discrimination signal $X(i)'$ is carried out. However, M of $ftMf$ in a formula 42 shows the number of an antenna element with the natural number, and f shows a frequency.

[0204]

[Equation 42]

$$X(i)' = \begin{bmatrix} ft_{11}(i) & ft_{12}(i) & ft_{13}(i) \\ ft_{21}(i) & ft_{22}(i) & ft_{23}(i) \end{bmatrix}$$

[0205] Next, the matrix-of-correlation presumption machine 1031 combines discrimination signal $X(i)'$ and the request processing signal BA , and it asks for the instant input matrices $RXMXM1$, $RXMXM2$, and $RXMXM3$ in each time of day in Matrix XM with a formula 44, a formula 45, and a formula 46 while it generates the matrix XM shown in a formula 43. Based on a formula 47, the instant input matrices $RXMXM1$, $RXMXM2$, and $RXMXM3$ are equalized, and the estimate $RXMXM$ of a matrix of correlation is calculated.

[0206]

[Equation 43]

$$XM(i) = \begin{bmatrix} X'(i) \\ BA(i) \end{bmatrix} = \begin{bmatrix} ft_{11}(i) & ft_{12}(i) & ft_{13}(i) \\ ft_{21}(i) & ft_{22}(i) & ft_{23}(i) \\ ba_{11}(i) & ba_{21}(i) & ba_{31}(i) \\ ba_{12}(i) & ba_{22}(i) & ba_{32}(i) \\ ba_{13}(i) & ba_{23}(i) & ba_{33}(i) \end{bmatrix}$$

[0207]

[Equation 44] $RXMXM1 = XM(1)$ and $XM(1)H$ [0208][Equation 45] $RXMXM2 = XM(2)$ and $XM(2)H$ [0209][Equation 46] $RXMXM3 = XM(3)$ and $XM(3)H$ [0210]

[Equation 47]

$RXMXM = (RXMXM1 + RXMXM2 + RXMXM3) / 3$, next the inverse-matrix computing element 1032 calculate inverse-matrix $RXMXM^{-1}$ of the estimate $RXMXM$ of a matrix of correlation. Moreover, the correlation vector presumption machine 1033 searches for discrimination signal $X(i)'$ and the instant correlation vectors [in / as shown in a formula 48, a formula 49, and a formula 50 using the request discrimination signal MX and the request discrimination signal BA / each time of day] $rxmb1$, $rxmb2$, and $rxmb3$.

[0211] Next, based on a formula 51, the correlation vector presumption machine 1033 equalizes the instant correlation vectors $rxmb1$, $rxmb2$, and $rxmb3$ on a frequency, and calculates the correlation vector estimate $rxmb$.

[0212]

[Equation 48] $rxmb1 = XM(1)$ and $MX(1)H$ [0213][Equation 49] $rxmb2 = XM(2)$ and $MX(2)H$ [0214][Equation 50] $rxmb3 = XM(3)$ and $MX(3)H$ [0215]

[Equation 51] It outputs " $w1 * w2$ " to multipliers 201 and 202 among the multiplication results Z at it, respectively while matrix multiplication of the matrix multiplication machine 1034 is carried out to the $rxmb = (rxmb1 + rxmb2 + rxmb3) / 3$ last and it asks it for the multiplication result Z with the estimate $RXMXM$ of a matrix of correlation, and the correlation vector estimate $rxmb$, as shown in a formula 52. In addition, the inside of a formula 51, $-a1 - a2 - a3 - a4$ are the signal weight stated to the above-mentioned 3rd operation gestalt.

[0216]

[Formula 52]

It can $Z=[w1* w2*-a1 -a2 -a3 -a4]^T$ Come, and are alike. More multipliers 201 and 202 It asks for a matrix product ($w1*FT1(i)$) and a matrix product ($w2*FT2(i)$), respectively, and by the adder (sigma) 300, a matrix product ($w1*FT1(i)$) and ($w2*FT2(i)$) are added for every frequency, and inner product signal $WHX(i)$ is called for.

[0217] The antenna weight $w1$ and $w2$ are updated so that the component except the request processing signal BA and the request discrimination signal MX may be oppressed among inner product signal $WHX(i)$ here. This prevents oppression with the request processing signal BA and the request discrimination signal MX without the need for oppression, and as substantially as the above-mentioned 1st and 2nd operation gestalt, since the signal component which originally has the need for oppression similarly can be oppressed, the Nur point can be formed in an effective target. Therefore, useless consumption of the degree of freedom of the adaptive array antenna of an SMI method can be held down.

[0218] For example, as shown in [alpha] drawing 22 , directivity can be formed by antenna elements 11 and 12.

[0219] That is, delay-GI outside signals other than the request processing signals BA and MX are oppressed among inner product signal $WHX(i)$, without oppressing the request discrimination signal MX. However, if a delay-GI outside signal and the request processing signal BA are received from the same, both a delay-GI outside signal and the request processing signal BA will be oppressed. Thus, among inner product signal $WHX(i)$, although the request discrimination signal MX is not oppressed and is left behind, the request processing signal BA may be oppressed depending on a receive direction.

[0220] Furthermore, the component of the request discrimination signal MX is left behind at least among inner product signal $WHX(i)$ by the antenna weight $w1$ and renewal of $w2$, and it is obtained. Here, since correlation with discrimination signal $X(i)$ is the largest signal among the request processing signals BS like ****, a signal with big receiving level can acquire the request discrimination signal MX as a component of the request discrimination signal MX among discrimination signal $X(i)$ by leaving behind the component of the request discrimination signal MX. Therefore, it can restore to the component of the request discrimination signal MX good.

[0221] In the above-mentioned 11th operation gestalt, the FFT circuits 801 and 802 are adopted and adaptive AREANTENA of an SMI method is constituted. In addition, the FFT circuits 801 and 802 Although explained per [which carries out FFT processing of the receiving OFDM signal $x1(i)$, and asks for the antenna weight $w1$ and $w2$ based on the signal on this frequency shaft by which FFT processing was carried out, respectively] example, you may make it be not only this but the following.

[0222] That is, without adopting the FFT circuits 801 and 802, adaptive AREANTENA of an SMI method is constituted, the receiving OFDM signal $x1(i)$ is replaced with the signal on the frequency shaft which carried out FFT processing, the receiving OFDM signal $x1$ on a time-axis (i) is adopted, and you may make it ask for the receiving OFDM signal $x1(i)$ antenna weight $w1$ and $w2$ on a time-axis.

(The 11th operation gestalt) With the **** 11 operation gestalt, as shown in drawing 22 , low pass filters (LPF) 1040 and 1041 are added to the configuration which the above-mentioned 10th operation gestalt shows.

[0223] In drawing 22 , a low pass filter 1040 searches for the discrimination signal LF 1 of a narrow-band $[=ft1(1), ft1(2)]$ based on discrimination signal $ft1(1) -ft1$ from the FFT circuit 801 (3). With this, a low pass filter 1040 searches for the discrimination signal LF 2 of a narrow-band $[=ft2(1), ft2(2)]$ based on discrimination signal $ft2(1) -ft2$ from the FFT circuit 802 (3).

[0224] By this, a low pass filter 1040 will output the discrimination signal LF of the narrow-band shown in a formula 53. That is, a low pass filter 1040 outputs the discrimination signals LF1 and LF2 of a narrow-band by taking out only the component of a predetermined frequency band among discrimination signal $ft1(1) -ft1(3) ft2(1) -ft(s)2(3)$.

[0225]

[Equation 53]

$$LF = \begin{bmatrix} LF_1 \\ LF_2 \end{bmatrix} = \begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \end{bmatrix}$$

[0226] Moreover, it connects between the FFT circuit 83 and the phase revolution machine 1000, and a low pass filter 1041 searches for the discrimination signal rLF of a narrow-band [=rf1 (1), rf1 (2)] based on the request discrimination signal rf1 from the FFT circuit 83 (1), rf1 (2), and rf1 (3). That is, a low pass filter 1041 outputs the discrimination signal rf1 of a narrow-band (1), and rf1 (2) by taking out only the component of a predetermined frequency band among the request discrimination signal rf1 (1), rf1 (2), and rf1 (3).

[0227] Next, only four sorts of amounts of phases (0 degree, theta**, 2theta**, 3theta**) carry out revolution processing of the request discrimination signal rf1 (1), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (1 theta), rf1 (1 2theta), and rf1 (1 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (1).

[0228] Furthermore, only four sorts of amounts of phases (0 degree, theta**, 2theta**, 3theta**) carry out revolution processing of the request discrimination signal rf1 (2), and the phase revolution machine 1000 outputs these request discrimination signals rf1 (2 theta), rf1 (2 2theta), and rf1 (2 3theta) by which revolution processing was carried out, and the request discrimination signal rf1 (2).

[0229] In addition, hereafter, request discrimination signal rf1(1) → rf1 (1 3theta) and rf1(2) → rf1 (2 3theta) are made into the request processing signal LBS, as shown in a formula 54.

[0230]

[Equation 54]

$$LBS = \begin{bmatrix} rf_1(1) & rf_1(2) \\ rf_1(1 \theta) & rf_1(2 \theta) \\ rf_1(1 2\theta) & rf_1(2 2\theta) \\ rf_1(1 3\theta) & rf_1(2 3\theta) \end{bmatrix}$$

[0231] next — **** — 11 — operation — a gestalt — correlator — 1010 — the above — the — ten — operation — a gestalt — having stated — a request — processing — a signal — BS — replacing — a request — processing — a signal — LBS — discrimination — a signal — X — (— i —) — ' — replacing — a narrow-band — discrimination — a signal — rLF — correlation — a value — K — ' — asking . moreover — a selection circuitry — 1020 — the above — the — ten — operation — a gestalt — substantial — the same — correlation — a value — K — ' — being based — a request — processing — a signal — LBS — inside — a narrow-band — discrimination — a signal — rLF — correlation — most — being large — a frequency — every — a request — discrimination — a signal — MX — ' — asking . Furthermore, it asks for request processing signal BA' other than request processing signal MX' among the request processing signals LBS.

[0232] Next, in a computing element 1030, while it replaces with discrimination signal X (i)', and the discrimination signal rLF of a narrow-band is inputted, replacing with the request processing signal MX and inputting request processing signal MX', it replaces with the request processing signal BA, and request processing signal BA' is inputted.

[0233] Then, the matrix-of-correlation presumption machine 1031 calculates inverse-matrix RXMXM-1 of the estimate RXMXM of a matrix of correlation while calculating [gestalt / above-mentioned / 10th operation] the estimate RXMXM of a matrix of correlation substantially similarly based on the discrimination signal rLF of a narrow-band, and request processing signal MX' with the correlation vector presumption machine 1033 and the inverse-matrix computing element 1032.

[0234] Moreover, the correlation vector estimate rxmb is calculated using the discrimination signal rLF of a narrow-band, request discrimination signal MX', and request discrimination signal BA' as substantially [the correlation vector presumption machine 1033] as the above—

mentioned 10th operation gestalt similarly. Furthermore, with the matrix multiplication vessel 1034, matrix multiplication of the estimate RXMXM of a matrix of correlation and the correlation vector estimate rxmb is carried out, antenna weight w_1 w_2 are calculated, and it is outputted to multipliers 201 and 202, respectively.

[0235] Since the component except the request processing signal BA and the request discrimination signal MX is oppressed among inner product signal WHX (i)' by the above, the same effectiveness is substantially acquired with the above-mentioned 10th operation gestalt. Furthermore, since the component of request discrimination signal MX' is left behind at least among inner product signal WHX (i)' and it is obtained, it can restore to the component of the request discrimination signal MX good substantially similarly with the above-mentioned 10th operation gestalt.

[0236] Moreover, while replacing with the request processing signal BS and adopting the request processing signal LBS in the operation of the correlation value of correlator 1010, it replaces with discrimination signal X (i)', and the discrimination signal rLF of a narrow-band is adopted. Here, like ****, the request processing signal LBS has a narrow frequency domain compared with the request processing signal BS, and the discrimination signal rLF of a narrow-band has a frequency domain narrow [the signal] like **** compared with discrimination signal X (i)'. For this reason, the amount of operations of the correlation value of correlator 1010 can be reduced compared with the above-mentioned 10th operation gestalt.

[0237] Furthermore, since correlation value K' of correlator 1010, the request processing signal LBS, and the discrimination signal rLF of a narrow-band are adopted when a selection circuitry 1020 asks for request processing signal MX'BA', the amount of operations of a selection circuitry 1020 can be reduced compared with the above-mentioned 10th operation gestalt.

[0238] Moreover, when a computing element 1030 calculates antenna weight w_1 w_2 , while replacing with discrimination signal X (i)' and adopting the discrimination signal rLF of a narrow-band, it replaces with the request processing signal MX, and request processing signal MX' is adopted. For this reason, the amount of operations of a computing element 1030 can be reduced compared with the above-mentioned 10th operation gestalt.

(The 12th operation gestalt) With a **** 12 operation gestalt, the low pass filters (LPF) 1040 and 1041 stated with the above-mentioned 11th operation gestalt are adopted, and it explains per [which constitutes the adaptive array antenna of PI method] example. The configuration in this case is shown in drawing 23 .

[0239] The adaptive array antenna of PI method in a **** 12 operation gestalt consists of antenna elements 11 and 12, a generator 60, the FFT circuits 83, 801, and 802, multipliers 201 and 202, an adder (sigma) 300, a phase revolution machine 1000, low pass filters (LPF) 1040 and 1041, and computing-element 1030A. Computing-element 1030A has matrix-of-correlation presumption machine 1031A, inverse-matrix computing-element 1032A, and matrix multiplication machine 1034A. In addition, in drawing 23 , the same sign in drawing 1 , drawing 2 , and drawing 22 shows the same object.

[0240] First, like the above-mentioned 11th operation gestalt, while a low pass filter 1040 searches for the discrimination signal LF 1 of a narrow-band $\{=ft_1(1), ft_1(2)\}$ based on discrimination signal $ft_1(1) - ft_1$ from the FFT circuit 801 (3) Based on discrimination signal $ft_2(1) - ft_2$ from the FFT circuit 802 (3), the discrimination signal LF 2 of a narrow-band $\{=ft_2(1), ft_2(2)\}$ is searched for.

[0241] Next, the phase revolution machine 1000 searches for the request processing signal LBS shown in a formula 53 like the above-mentioned 11th operation gestalt based on the discrimination signal rLF of the narrow-band from a low pass filter 1041 $\{=rf_1(1), rf_1(2)\}$.

[0242] Next, it computing-element 1030A Sets and matrix-of-correlation presumption machine 1031A combines the discrimination signals LF1 and LF2 and the request processing signal LBS of a narrow-band, and while generating the matrix FB shown in a formula 55, the above-mentioned 10th operation gestalt and the substantial estimate [in / similarly / Matrix FB] RFBFB of a matrix of correlation are calculated.

[0243]

[Equation 55]

$$FB = \begin{bmatrix} LF_1 \\ LF_2 \\ LBS \end{bmatrix} = \begin{bmatrix} ft_1(1) & ft_1(2) \\ ft_2(1) & ft_2(2) \\ rf_1(1) & rf_1(2) \\ rf_1(1 \ \theta) & rf_1(2 \ \theta) \\ rf_1(1 \ 2\theta) & rf_1(2 \ 2\theta) \\ rf_1(1 \ 3\theta) & rf_1(2 \ 3\theta) \end{bmatrix}$$

[0244] Next, inverse-matrix computing-element 1032A calculates inverse-matrix RFBFB-1 of the estimate RFBFB of a matrix of correlation. Furthermore, matrix multiplication machine 1034A outputs antenna weight w1 w2 to multipliers 201 and 202 among multiplication result Z', respectively while asking for multiplication result Z' using the formula showing in a formula 56. In addition, the inside of a formula 55, -a1 -a2-a3 -a4 is the signal weight AH stated to the above-mentioned 9th operation gestalt.

[0245] Here, antenna weight w1 w2 are updated so that power of the component except the request processing signal LBS may be made into min among inner product signal [of an adder circuit 300] WHX (i)'.

[0246]

[Equation 56]

$$Z' = [1 \ 0 \ 0 \ 0]^T \times R_{FBFB}^{-1} \\ = [w_1^* \ w_2^* \ -a_1 \ -a_2 \ -a_3 \ -a_4]^T$$

Furthermore, when computing-element 1030A calculates antenna weight w1 w2, while the discrimination signal rLF of a narrow-band is adopted, the request processing signal LBS is adopted. The frequency band of the discrimination signal rLF of a narrow-band is narrow here compared with the frequency band of discrimination signal X (i)' stated with the above-mentioned 10th operation gestalt, and the frequency band of the request processing signal LBS is narrow compared with the frequency band of the request processing signal BS stated with the above-mentioned 10th operation gestalt. Therefore, computing-element 1030A can reduce the amount of operations compared with the time of using discrimination signal X (i)' and the request processing signal BS.

[0247] In addition, if it is two or more pieces as the number of antenna elements in operation of this invention, it is good without limit.

[0248] Furthermore, in carrying out frequency discrimination of the various signals, the example which adopted FFT processing was explained with each above-mentioned operation gestalt, but various kinds of frequency discrimination processings, such as not only this but DFT processing, may be adopted.

[Translation done.]

*** NOTICES ***

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- 1.This document has been translated by computer. So the translation may not reflect the original precisely.
- 2.**** shows the word which can not be translated.
- 3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 1st operation gestalt of this invention.

[Drawing 2] It is drawing showing the result of the simulation of the adaptive array antenna of the MMSE method of the above-mentioned 1st operation gestalt.

[Drawing 3] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 2nd operation gestalt of this invention.

[Drawing 4] It is drawing showing the detail configuration of the delay circuit shown in drawing 3 .

[Drawing 5] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 3rd operation gestalt of this invention.

[Drawing 6] It is drawing showing the detail configuration of the FFT circuit shown in drawing 5 .

[Drawing 7] It is drawing showing actuation of the delay circuit shown in drawing 5 .

[Drawing 8] It is drawing showing actuation of the FFT circuit shown in drawing 6 .

[Drawing 9] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 4th operation gestalt of this invention.

[Drawing 10] It is drawing showing actuation of the matched filter and delay circuit which are shown in drawing 9 .

[Drawing 11] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 5th operation gestalt of this invention.

[Drawing 12] It is drawing showing the detail configuration of a request signal selection circuitry shown in drawing 11 .

[Drawing 13] It is drawing showing the configuration of the adaptive array antenna of the MMSE method of the 6th operation gestalt of this invention.

[Drawing 14] It is drawing showing the detail configuration of the equal circuit shown in drawing 13 .

[Drawing 15] It is drawing showing actuation of the equal circuit shown in drawing 14 .

[Drawing 16] It is drawing showing the configuration of the adaptive array antenna of PI method of the 7th operation gestalt of this invention.

[Drawing 17] It is drawing showing the result of the simulation of the adaptive array antenna of PI method of the above-mentioned 7th operation gestalt.

[Drawing 18] It is drawing showing the configuration of the adaptive array antenna of PI method of the 8th operation gestalt of this invention.

[Drawing 19] It is drawing showing actuation of LPF of drawing 18 .

[Drawing 20] It is drawing showing the configuration of the adaptive array antenna of PI method of the 9th operation gestalt of this invention.

[Drawing 21] It is drawing showing the configuration of the adaptive array antenna of the SMI method of the 10th operation gestalt of this invention.

[Drawing 22] It is drawing for explaining actuation of the above-mentioned 10th operation gestalt.

[Drawing 23] It is drawing showing the configuration of the adaptive array antenna of the SMI

method of the 11th operation gestalt of this invention.

[Drawing 24] It is drawing showing the configuration of the adaptive array antenna of PI method of the 11th operation gestalt of this invention.

[Drawing 25] It is drawing showing a format of an OFDM signal.

[Drawing 26] It is drawing for explaining the input signal of the adaptive array antenna of an MMSE method.

[Drawing 27] It is drawing showing the configuration of the adaptive array antenna of the conventional MMSE method.

[Description of Notations]

40 A—MMSE computing element, 30, 51, 52 — 60 An adder, 70 — Generator.

[Translation done.]

